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ABSTRACT

Population projections are "what if" computational exercises. Given selected assumptions about future trends in fertility, mortality, and migration, population trends can be projected. Government and business planners need this information, and they also require enough time to put facilities in place to meet future needs. Everyone benefits from a clearer understanding of population dynamics and social changes. The different aspects of preparing projections, such as obtaining base data and selecting starting and future levels of rates, are highlighted. Both preparers and users need to carefully check the assumptions chosen for the projections since the reliability of the projections depends on those assumptions. The rules of thumb for reliability are: (1) the shorter the projection period, the more reliable the projection is likely to prove; (2) the larger the geographic areas projected, the more reliable the projection is likely to be; and (3) the lower the current fertility and the higher the current life expectancy, the greater will be the reduction in the projections' likely margin of error. Major sources of data and projections on world, regional, national, subnational, and local areas are discussed, as are the difficulties in utilizing data for developing countries. (Author/SM)

POPULATION BULLETIN
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Understanding Population Projections

By Carl Haub

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Abstract— Population projections are *not* forecasts, nor do demographers predict the future. Projections are "what if" computational exercises: given selected assumptions about future trends in fertility, mortality, and migration, a population x years ahead might be this; with other assumptions it might be thus. Planners, in government and business, need such information and also need enough time to put facilities in place to meet future needs, while everyone needs clearer understanding of population dynamics and social changes. Discussions of how to prepare projections—obtaining base data, selecting starting and future levels of rates, variant series, the mathematics involved—lead to warnings for both preparers and users to carefully check the assumptions chosen for the projections. The *reliability* of the projections stems from the assumptions selected.

Rules of thumb for reliability: 1) the shorter the projection period, the more reliable the projection is likely to prove; 2) the larger the geographic area being projected, the more reliable the projection is likely to be; 3) the lower the current fertility and the higher the current life expectancy, the greater will be the reduction in the projection's likely margin of error.

Major sources of data and projections on world, regional, national, subnational, and local areas are discussed, as are the difficulties with data for developing countries.

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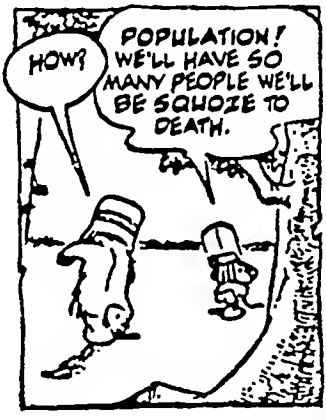

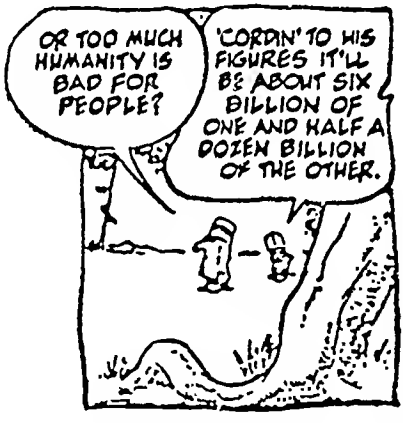

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Understanding Population Projections

By **Carl Haub**

Carl Haub is Director of Demographic Analysis and Public Information for the Population Reference Bureau, coming to the Bureau in 1979. He received the M.A. in Sociology (Demography) in 1977 from the Center for Population Research of Georgetown University, Washington, D.C. His duties include preparation of the annual World Population Data Sheet *and serving as Demographic Editor of* Population Today *as well as daily responses to public and media inquiries on demographic matters. His use of population projections for informational purposes and research has also led to an interest in microcomputer applications of projections.*

He gratefully acknowledges the assistance of Machiko Yanagishita in the preparation of projections used in this Bulletin *and the advice of Professor George J. Stolnitz of Indiana University, PRB's current Andrew W. Mellon Foundation Visiting Scholar.*

"At the same ratios of increase which we have maintained, on an average, from our first national census of 1790 until that of 1860, we should in 1900 have a population of 103,208,415 . . . our country may be as populous as Europe now is . . . our territory, 73 1/3 persons to the square mile, being of capacity to contain 217,186,000."[1]

Thus did President Abraham Lincoln venture into the uncertain sphere of population projections, with an opinion on future "carrying capacity" tossed in for good measure. Fortunately, Lincoln's reputation did not hinge upon the accuracy of his projections—the population at the turn of the century would reach but 76 million. Still, his consideration of the matter is symbolic of the interest in one of the demographer's more popular products, the population projection.

Interest in projections involves much more than a simple curiosity about what may lie ahead. Having some sense of the number of people expected, their age distribution, and where they will be living provides city planners and local governments, for instance, sufficient "lead time" to prepare for coming needs in terms of schools and traffic lights, or reservoirs and pipes to deliver water supplies. Businesses have a vital interest in the coming demand for their products and services. Much of that demand may be age-related: a manufacturer of infant formula will be quite concerned with projected births, while the fact that more people are living longer is of obvious interest to the health care industry. If declines are projected in the number of people in the normal family-formation ages, housing contractors worry.

Projections provide a singular look into the future, even if that preview is a flawed one. The fact that projections can be wrong, even very wrong, can lead to undeserved scathing reviews. Still, they are indispensable, if not for their eventual accuracy, for the very process of making them. Population projections are not final products, placed on the table, and let to stand for all time. They provide the means for ongoing evaluation and re-evaluation. Demographers will quickly point out that projections are useful for 5, 10, or 20 years—perhaps more—depending upon one's purpose. Just as

soon as a series of projections has been completed, it is time to begin anew, watching their progress and adjusting for unforeseen eventualities. This is the heart of projections; the exercise of monitoring shifts, of making "rolling adjustments," leads to a more complete understanding of population change. The real value of projections, then, may not lie in the product, but in the insights into population dynamics and social change they provide.

While a census can provide a complete picture of a population when its members were being counted, only a projection can suggest the changes that are to come. How many people will there be? Where will they live—north? south? in cities? suburbs? In how many households will they live? Will they be older or younger? Will their numbers be growing rapidly? Slowly? Or declining? While the true course of our demographic future cannot be fully known, projections can at least point us in the proper direction, or alert us to some unfortunate situations.

World population projections have been a cause of considerable concern, particularly because of the population "explosion" of the post-World War II years. The probable consequences of rapidly expanding human numbers have been the subject of lively debate. Recently, that debate has been joined in controversy by the issue of population decline resulting from the very low birth rates in some countries. Books on these concerns range from Paul Ehrlich's "The Population Bomb" to Ben Wattenberg's "The Birth Dearth."

While there is strong interest in and need for projections, they do have limitations. There are vast differences between a short-range projection of births in a developed country and a long-range projection of the total population of Asia. Discussions which focus on population projections are an important element of planning in both the more and less developed countries, but much can be learned from a closer look at these statistical prognoses. In this *Bulletin,* we will look at how projections are created, their reliability, and the sources of the more widely used population projections.

Caveat Emptor

Projections are *not* forecasts.

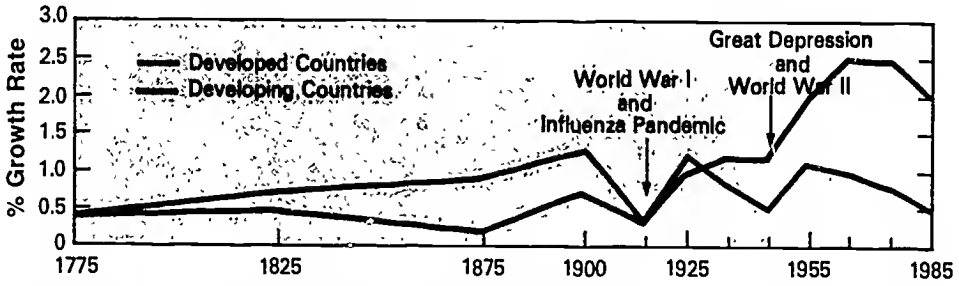
Leon Bouvier has remarked that it might be better if we say that the U.S. Bureau of the Census has released new *assumptions* rather than new projections.[2] All too often, though, the demographer's subjunctive becomes the media's "will." Paul Demeny summarized the perception of population projections in the public mind in incisive fashion:

> It would not be surprising if the very proliferation of alternative population futures—available off the shelf in any shape and color, as it were—had by now eroded the credit accorded to any particular projection. ... Owing to the ministrations of the communications media, certain visions of the demographic future tend to capture disproportionate attention and, at any given time, tend to dominate public discussion of population issues. Unhappily, such selectivity appears to be governed more by the search for novelty than by the solidity of the arguments on which particular projections rest.[3]

Projections can be tricky things. It is essential, then, for both preparer and user to understand the problems inherent in the actual process. Those making projections should anticipate how they will be used and interpreted, especially since the results are "plugged into" many policy studies as denominators for rates or routinely used for planning purposes.

Since many people for whom demography is not a daily concern receive their information through the media, the way projections are interpreted in the press or on television is of considerable importance. Legislators who must consider a wide variety of topics gather information or impressions from their morning paper, as others do. Those who prepare and issue statistical studies and

Figure 1. How History Has Changed Population Trends



Sources. Ansley J. Coale. The History of Human Population. *Scientific American*, Sept. 1974, p 47, and United Nations, World Population Prospects as Assessed in 1982." UN Population Division. Dec 1983

prognoses should see that they are properly explained for people without technical training in their field. The media provide demography with its widest audience and, in many ways, its most important one.

When projections find their way into the media, they are quite often caught between a rock and a hard place. The media require a concise answer to a seemingly simple question: what, for example, will world population be 20 years from now? No long explanations are requested or wanted, just a number. Here is where the system falls down. The media need an answer, but unwittingly ask the wrong question. Demographers will respond that future populations will depend upon unforeseeable trends in birth and death rates, an answer replete with *ifs* and *buts*. The media are not satisfied; the demographer is frustrated. To compound the problem, the *soft news* of demography must be condensed into the language of press releases if the real story is to be noticed at all. This can lead to an over-simplifying of the results, and the loss of important information.

One instance will serve as an example of a breakdown in communications between demographers and the "outside world." In 1982, many major newspapers ran articles stating that the United Nations had lowered the world population projection for the year 2000 by 20 percent,[4] evidence that the population "bomb" had "fizzled."[5] The reports said while a world population of 7.5 billion had previously been predicted for 2000, that expectation had just been greatly reduced, to 6.1 billion people. The population explosion, it seemed, was coming to a much-welcomed end. At the time, 2000 was but 18 years away and such a change in the projections would have truly been a major demographic event as well as a major media story.

This sudden reduction of the UN's projection for the year 2000 had not occurred at all, although it is not difficult to see how a writer could have been misled. A UN publication discussing the 1982 projections had correctly pointed out that *if* birth rates had not decreased since the early 1950s, world population in 2000 would likely be 7.5 billion.[6] But birth rates *had* declined, and the projection for 2000 was 6.1 billion—approximately the same figure the UN had been projecting for the past 25 years. The UN report had merely sought to make a point about the effect of past decreases in the birth rate on world population size in 2000, but reporters, not being trained as demographers, inadvertently misread the text and mistook the meaning.

Such reports make a strong impression on the public mind. Given the large amount of information swamping us daily and the large number of "crises" reported by the media—some real, some not—the announcement that the popu-

Table 1. UN World Population Projections, Assessments of 1951-1984

(Medium Series)

Year of Assessment	Projection Year 1960	1980 (in millions)	2000
1951	—	3,277	—
1954	2,768	3,628	—
1958	2,910	4,220	6,280
1963	2,998	4,330	6,130
1968	—	4,457	6,494
1973	2,986	4,374	6,254
1978	3,026	4,413	6,196
1980	3,037	4,432	6,119
1982	3,014	4,453	6,127
1984	3,019	4,450	6,122

Sources: 1951-1973—"Prospects of Population Methodology and Assumptions," *Population Studies* No. 67, United Nations, New York, 1979. 1978-1984—United Nations *Assessments*, various issues

lation explosion was over would undoubtedly find a receptive audience. There is also, perhaps, something appealing in the thought of demographers sent scurrying back to their computers—a refreshing image of the "experts" proven wrong.

And, of course, sometimes demographers are off-base. No one foresaw the baby boom, for instance. A reminder of the havoc wrought by the horsemen of the Apocalypse—disease, famine, and war—should be engraved on every projection as a reminder that reality is not bound by our thoughts of what the future holds.

How Many Projections?

Knowing that they know not the future, demographers often issue multiple "series" of projections for a country or area. Such alternatives better reflect the "what if" nature of the document: if the future birth rate goes down by so much, then the population size will be Y; if it goes down even more, it will be Z. Such a procedure obviously results in a variety of alternative futures with some producing larger populations than others. But, as is often the case, users of projections do not want or cannot use multiple answers to a single question, and the pressure is on to pick one of the series.

If the series contains an odd number of projections, often three, with labels such as "high," "medium," and "low," the decision is obvious: pick the "medium," treating the others as outside possibilities or statistical curiosities. In many instances, the middle projection in a series may be highlighted or presented in more detail, perhaps recognizing that most users will select it in any event. If the number of projections issued is an even number, however, selecting a single projection becomes more problematic. The U.S. Bureau of the Census did just that for many years, giving fundamentally equal treatment to its four series of projections. In so doing, the Bureau was sending a clear message that it did not wish to telegraph any preference but, under a given set of assumptions, could illustrate a variety of outcomes. The 1953 report containing the Bureau's projections for the U.S. population stated:

> Many persons need some indication of the approximate size of the population of the United States, by age and sex, at some future dates. The projections of the population offered here are intended primarily to facilitate planning by indicating the size of the population which would result if assumed levels of births, deaths, and immigration were to be realized. It is felt that all of the projections shown are reasonably possible.[7]

Very well put. Multiple series do serve an important purpose: a range of reasonable future scenarios provides a sense of likely margins of error for the user.

Still, the selection of a "most probable" choice does have its value. In subsequent years, the Bureau has highlighted one of the projections as a "middle" series. Today the Bureau publishes 30 series and suggests one as a medium projection. There are very good

reasons for doing so in that the selection of a series avoids a potentially chaotic situation for users who must have one set of numbers for their own purposes. The Bureau also "tracks" that series for performance and will rerun the projections if they are getting out of line.[8]

The appropriate use of population projections becomes clearer as we take a closer look at how they are actually made and the difficult decisions a demographer must face during the process.

How Projections Are Made

A population projection is a computational exercise which seeks to portray a future population's size and age-sex distribution. As such, it must first make assumptions about the future course of birth and death rates and the effects of migration. A population estimate carries forward a population only to a present date, from a prior census or other estimate, based upon known or estimated changes resulting from fertility, mortality, and migration.

The simplest method of projecting a population total is to apply an assumed growth rate for some period of time. Such a **growth rate method** could be used to prepare a short-range projection and if only a projection of the total population were needed. For example, if a country had a population of 25,000,000 with an annual growth rate of 2 percent and we needed to project that population one year later, the projected population would be calculated by $P2 = P1 \times (1 + r)$ where P1 = the beginning population, P2 = the population one year later, and r = the growth rate (expressed in decimal form):

$$25{,}500{,}000 = 25{,}000{,}000 \times (1 + .02)$$

This simply means that if a population of 25,000,000 were to grow during a one-year period by 2 percent, that growth would equal 25,000,000 multiplied by .02, or 500,000. Carrying that forward for one more year, starting with the "new" population of 25,500,000 we have:

$$26{,}010{,}000 = 25{,}500{,}000 \times (1 + .02)$$

The increase in the first year was 500,000 (25,000,000 x .02); in the second year, it was 510,000 because the base population increased from 25,000,000 to 25,500,000 (25,500,000 × .02 = 510,000). In other words, the rate of change remained constant at 2 percent but the *amount* by which the population grew increased as the base population increased. A growing population has an increasing amount of change even if the rate of change is constant. This is recognizable as "compound interest."

To simplify matters, it is not necessary to recalculate change year by year for longer periods since a simple formula exists to do that. If we need to project the population for 11 years at 2 percent, the formula is

$$P2 = P1 \times (1 + r)^t$$

which becomes

$$P2 = P1 \times (1 + .02)^{11}$$

$$P2 = P1 \times (1.02)^{11}$$

$$31{,}084{,}358 = 25{,}000{,}000 \times (1.02)^{11}$$

This is the geometric formula for change. It is exactly equivalent to multiplying the beginning population of 25,000,000 11 times by 2 percent.

The geometric formula has one flaw when applied to changing populations, however. It assumes that a population only grows in fixed intervals. That is, our population begins at 25,000,000 on January 1, remains at 25,000,000 for 12 months and only then increases by 2 percent on December 31st. Of course no population increases or decreases in such a manner. People die and babies are born every day. A better method is needed to allow for continual change. This is provided by an alternative to the geometric formula, the **exponential growth formula**

$$P2 = P1 \times e^{(rt)}$$

Here, all is the same except that e = the base of the natural logarithm, or 2.718. This formula allows for *continuous change*, or daily compounding, as banks often refer to it. To repeat the above example with the exponential formula:

$$31{,}151{,}208 = 25{,}000{,}000 \times 2.718^{(.02 \times 11)}$$

The exponential "compound interest" formula used works for any quantity, be it a population or money on deposit in a bank. Note the slightly larger population produced by the exponential formula over the geometric.

The descriptive sense of the word "exponential" should not be confused with the technical meaning. It does not mean "fast" nor connote rapid or inexorable growth, since there can easily be slow (and even negative) exponential change. In fact, the exponential formula does not produce significantly larger results than the "geometric" formula used for annual compounding unless the growth rate is comparatively large and/or the projection period is quite long.

The above formula is also the source of the famous "population doubling time." Dividing the number 70 by the annual growth rate will yield the number of years in which a population will double in size, if—and this is a very large "if"—the growth rate remains constant.[9] A population with a constant growth rate of 2 percent, for example, will double in 35 years.

While growth rate methods do help indicate how populations grow, their practical value is limited. The questions projections try to address nearly always require data by age and sex. Growth rate methods may be able to project the total size of a population, but do not provide the specific an-

Box 1. Cohort-Component Projection

The table to the right illustrates the process of using the cohort-component method to "survive" a population and to project the number of births during a five year period. (Any effects of immigration have been omitted.)

This fictitious female population has been projected for a five-year period by using survival rates from an appropriate life table. Thus the population aged 15-19 in the first year is multiplied by the survival rate, to find the proportion which will survive the five-year period: 712 x .9747 = 694. By simple subtraction, we can easily see that 18 deaths occurred in this age group in the five-year period: 712 − 694 = 18. The number of births is calculated by applying the age-specific birth rates to the average population of each childbearing age-group. The age-specific rate of .3504 indicates that 35 percent of the women 20-24 will give birth during each year: (605 + 694) ÷ 2 = 650 women and 650 x .3504 = 228 births; the births must be multiplied by five since there are five-year age groups. These newborns, if they survive, in turn form the 0-4 age group at the end of the 5th year (+ 5). That age group is obtained by multiplying female births by the first survival rate: 1,694 × 0.8134 = 1,378.

Sample Cohort—Component Projection of A Female Population

	Year t	Survival Rate	Year t +5	ASFRs*	Births
0-4	1,192	0.8134	1,378	ASFRs*	Births
5-9	974	0.9220	1,099	—	—
10-14	827	0.9784	953		
15-19	712	0.9807	811	0.1869	712
20-24	605	0.9747	694	0.3504	1,138
25-29	503	0.9702	587	0.3205	873
30-34	418	0.9682	487	0.2266	513
35-39	374	0.9665	404	0.1085	211
40-44	325	0.9626	360	0.0199	34
45-49	280	0.9631	313	0.0082	12
50-54	239	0.9536	267		
55-59	197	0.9331	223		
60-64	155	0.8985	177		
65-69	115	0.8452	131		
70-74	75	0.7565	37		
75+	62	0.5328	73	- 40 + 33	
Total	7,053		8,044		

3,493 Total births
1,694 Female births
TFR = 6.1

*Age-specific fertility rates

Note: In this example the survival rates for the two oldest age groups (70-74 and 75+ in year t) have been combined for simplification.

swers needed when the question concerns the future number of, say, schoolchildren. A population's age and sex structure often has far more socioeconomic impact than total population size. This is where the cohort-component method comes in.

The Cohort-Component Method

The cohort-component method is the principal method used for the demographic projection of national populations. Introduced by Pascal Whelpton in the 1920s,[10] the cohort-component method projects a population by individual age-sex *cohorts*, e.g., separate age and sex groups such as females ages 0-4, 5-9,. . .85+, and by separate *components*, i.e., fertility, mortality, and migration. With this method, year-to-year effects of the individual components of change (births, deaths, and migration) are taken into account for each age and sex group and then combined to produce the new age-sex groups for the next time period. To project the population of males aged 10-14 five years from now, we begin with those aged 5-9 today, deduct the number of deaths expected in that group, and add or subtract the amount of net migration (immigrants minus emigrants or vice versa). The process is actually quite simple, since that age-sex group can only change in size by loss through death and emigration or gain by immigration. The youngest age group, those 0-4 at the end of the projection period, are the births during the five-year period, less any infant-child mortality, and addition or subtraction by migration.

The cohort-component method, by definition, reflects all vital-rate differences between age and sex groups. Since female life expectancy is normally higher than male, with the result that female survival at each age is different, applying the same survival rates to both males and females would clearly lead to error. Also, populations of developed countries have comparatively large proportions of persons in the older age groups (65+) so that their populations have proportionately more deaths than a developing country with a comparable population size. In some countries, migration can be highly selective for sex. The oil-producing Persian Gulf states, for example, have experienced a large influx of males of working ages.

The cohort-component method properly "weights" a population total for the varying likelihood of vital events such as births and deaths in its age-sex distribution. Projections require the calculation of the annual number of births which, in turn, requires consideration of the size of the population of females of childbearing ages.

Population change in a given area is a complex blend of varying patterns of birth and death rates and of movement in or out of the population, and the cohort-component method provides a faithful model of these dynamics. A closer look at the mechanics of projections is warranted, but we should first consider the sources and reliability of the "base data" needed before the projection can be run.

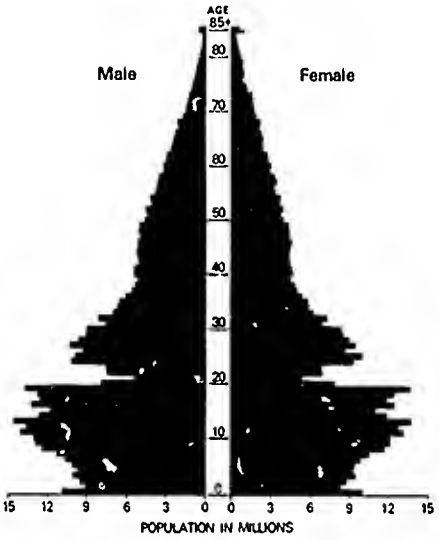
Base Data

Every projection has a starting point. Most often, the last date for which the needed data are available is the practical start. Data on the population's size and age-sex composition must be obtained. Then rates of population change—birth, death, and migration—must be decided. Selecting a starting point is the first step in the process, but it can be a major one.

The National Census

In nearly all developed countries and in some developing nations, the base data used for the population at the beginning of the projection period are easily available. Demographers typically spend more time pondering the assumptions to be used. But for most developing coun-

Figure 2. China: Population Pyramid, 1982 Census



Source: *Beijing Review*, January 16, 1984

tries, containing the majority of world population, matters may not be so simple.

To begin with, at leas' one national census is highly desirable as a basis for identifying the initial population. The census in question must, of course, be published in sufficient age detail and deemed to be of adequate quality. Not all countries have produced a reasonably usable census. Of special importance is China's 1982 Census, in many respects its first enumeration deemed to be of high quality. This national count provided data which had been seriously lacking, for over one-fifth of the world's population. A few smaller countries such as Oman, Qatar, and Chad have never taken a national tally. Still others have not organized one for decades, often for political reasons. Lebanon's last count was in the 1930s, distributing political power on the basis of the numbers of people belonging to different religious groups. The numbers have shifted, no census has been permitted, and a civil war is being fought. Nigeria, which is home to almost one of every five Africans, last attempted a census in 1973. This count was rejected when it was felt the individual state counts might be inflated. Saudi Arabia has also rejected its censuses as being of inferior quality. And although the Soviet Union does take regular censuses, there are few data published from its 1979 count, including the all-important age-sex distribution.

In a report and inventory of the availability of good "benchmark" data, the U.S. National Academy of Sciences noted:

> Although a census is, in effect, a snapshot of a population at a given point in time, it also provides a basis for inferences concerning past and future changes. Comparison of censuses taken at different times provides information concerning the growth or decline of the total population and of groups of people, as well as changes in sub-areas of the country.[11]

The Academy's comment on "sub-areas" alludes to one of the most important reasons for national counts, the need for small-area detail so vital for planning. While it is true that needs for many demographic measures can be met with sample surveys, the census, in turn, provides the necessary "sampling frame" for such surveys themselves.

Once taken and published in the necessary detail, a census should be evaluated for quality. This is an issue for all countries, although a more serious one for developing nations. Several broad concerns emerge, the accuracy of age reporting, different rates of undercounting males and females, and the accuracy of the count of infants and very young children. Common age reporting problems include "heaping" on a convenient value such as an age ending in 0 or 5 when the true age is not known and overstating age among the elderly.

Overall measures have been developed to measure the extent of "age-heaping," since it would not be expected

that any single ending digit would predominate. In Bangladesh's 1974 Census, for example, there were 2,812,695 people who gave their age as 30 and only 124,209 who said they were 31.[12] An index proposed by Robert J. Myers[13] summarizes the extent of age heaping; the closer the index is to zero, the better the quality of age reporting. Among developing countries, Myers' Index ranges from near-zero (Argentina) to 30 or more (India, Bangladesh).[14] Other indexes, such as the United Nations *Age-Sex Accuracy Index,* seek to measure the reported population's deviation from a "normal" distribution,[15] one that has not been greatly affected by atypical events such as sharp swings in the birth rate, wars, famines, or disproportionate migration.

The extent to which a population has been undercounted (or overcounted) is another clear concern. Many countries attempt to evaluate their censuses by comparing the results to ongoing population registers or by another interview of households to determine who may have been missed or counted more than once. The censuses may or may not be officially adjusted; most often, they are not. The 1970 Census of Indonesia contained a mysterious "hollow" age group, beyond the expected effects of migration, in which there were fewer than expected persons aged 10-19, and this cohort remained smaller in the 1980 Census as well.[16] Ethiopia's 1984 Census counted 42 million people, 10 million more than previously estimated, while Guatemala's 1981 count came in somewhat low. Tales of census takers' fears of travelling into certain areas are not uncommon. In some cases, disputed territory will cloud the final tally, such as the Israeli-occupied West Bank of Jordan or the Vale of Kashmir, claimed by both India and Pakistan. Methods for counting nomads (e.g., the "water hole" or the group assembly method) have been suggested,[17] but these populations are often simply guess-estimates. In Botswana and other countries, census takers try to help respondents state their ages by listing the dates of major events such as famine years or visits by royalty. For many countries, the first census is an important learning process, with many obstacles that cannot be anticipated.

Countries devise many techniques to assure an accurate count, such as a splash of green paint on doorways in Pakistan or requiring citizens to carry a census receipt as in the Soviet Union. In some cases, the actual taking of a census may be disputed as an unnecessary invasion of privacy. The Netherlands has not taken a census since 1971 and West Germany finally took its count in 1987, seven years later than planned, because of citizens' objections. While West Germans do register their place of residence at their local city hall, it is thought some persons in the more mobile younger age groups are counted more than once, hence an accurate census would assist in determining the "true" population of that country.

While undercounts or overcounts are probably more serious in developing nations, they may also be an important consideration in developed countries. In the United States, the anticipated count for the 1980 Census was 221 million. But when the results were in, the actual tally amounted to 226.5.[18] only a 2.4 percent difference, but there were 5.5 million additional people involved, more than the population of Denmark. The larger number is likely to have resulted from an intensified effort to obtain a complete count, particularly of minority groups such as blacks and Hispanics. Undercounts can be especially troublesome for minorities. Congressional seats are apportioned and federal funds allotted on census headcounts. Lawsuits by states against the Census Bureau, because of this issue, are common. The Census Bureau's estimate of overcount or undercount varies according to the number of illegal aliens assumed to reside in the country. Bureau estimates range from 1.0 to 1.8 percent undercount, a marked improvement over earlier counts (the

1970 undercount has been put at just under 3 percent). Black males were probably undercounted by about 6 percent.[19] Despite the fact that many countries do attempt to measure the completeness of census coverage, adjustments are not often made. Australia, Finland, Spain, and Sweden are examples of countries that do adjust, although the data may only be used for special purposes.[20] Nonetheless, census counts which vary noticeably from an expected number cause other problems, such as the need to adjust birth and death rates. After 1980, the provisional U.S. crude birth rate was adjusted from 16.2 births per thousand to 15.8, because the estimated denominator (the larger 1980 count) had increased.[21]

The national census can also be used as an instrument to measure levels of fertility and mortality. This can be done directly, in the form of questions on children ever born to a woman, births and deaths in the household in the past 12 months, and, indirectly, inferred from the age-sex distribution itself. The accuracy of the responses to the questions will vary greatly from country to country and is an intense object of study by demographers who specialize in estimating errors in and adjusting census measures of fertility and mortality. Children ever born may be underreported because of a taboo against boasting about one's fertility, or forgetting a child who died in infancy. The latter, of course, also has implications for estimates of infant mortality.

The national census, while a vital source of fundamental demographic measures for a projection of the future population, also poses the question. How well do we know a population today?

Selecting a Base Population

In practice, the most recent census will be used for the beginning of the projection period. This may well mean using a base population ten or more years old. If no base population is available from a census, there may be information from a national survey or from estimates prepared by individual demographers that can be used to approximate one. An estimate may have little basis other than a rough guess as to the country's population size, combined with the age-sex distribution of a neighboring country whose cultural and health conditions are thought to be roughly similar. In countries with good data, the national statistical agency may issue population estimates for years between censuses which are known to be quite reliable. The U.S. Bureau of the Census, for example, issues annual population estimates by age and sex which make quite sound base populations for projections.[22] Base populations obtained from demographers who study particular countries have already often been adjusted to compensate for obvious errors. If, for example, the population aged 0-1 is much less than one-fifth of the age group 0-4, and the birth rate is widely believed to be constant, some adjustment must be made to correct the apparent undercount of infants. Many demographers use the excellent manuals published by the United Nations for the evaluation and adjustment of demographic data, augmented by the work of demographers specializing in this area.

Since the population data for a given country may appear as either "raw" or "adjusted," the process of selecting the beginning population requires some care. Projections should never be presented "cold" to the user. A report specifying the assumptions and overall logic used, no matter how brief, should always accompany the results.

Selecting a Starting Fertility Level

Before considering fertility assumptions, it would first be best to consider what "fertility" means in the context of projec-

tions. As used here, it is the average number of children a group of women have in a given time period. Women born in 1930 have usually completed their childbearing by 1980, and their childbearing history is known. But what can we say of women today? Their current rate suggests their eventual fertility, based upon national childbearing patterns by age, but that is all.

A country's fertility levels will exert a powerful influence upon its future overall population size and age-sex distribution. Its effects are most noteworthy when the country's fertility is quite high. While in many developing countries the sharp increase in postwar growth rates has been due to decreases in death rates, future population growth rates will be largely dependent upon changes in the birth rates to come. This is particularly true for developing nations whose life expectancy has risen to moderately high levels, say, 55-60 years at birth. And fertility plays a vital role in the age-sex distribution of the population to come since, for most countries, it is the primary way in which the population receives new members.

The selection of a fertility level for the start of the projection is a basically simple process for countries with accurate and timely data. Nearly all such countries have relatively low birth rates and, in recent years, many have experienced comparatively constant fertility as well. The measure most often used to establish the initial overall fertility level is the **total fertility rate (TFR)**, summarizing the birth rates of women in the childbearing years (15-49 in most countries, 15-44 in the U.S.). A TFR of 1.8 for the United States in 1985 indicates that, at the 1985 fertility rates by age for women 15-19—40-44, women would average 1.8 live births during their lifetimes.*

The age patterns of fertility also vary substantially among countries. In a developing country, childbearing may be heavily concentrated among women at the younger ages of 15-24, while in a developed country, childbearing may peak sharply at 25-29. This can make quite a difference if past swings in the birth rate, such as a baby boom, have resulted in a "bulge" in the numbers of potential mothers in certain age groups. In West Germany today, just such a bulge in the peak childbearing ages is causing the number of births to remain much larger than they will be when much smaller age groups, now below age 10, enter their childbearing years. An increase in the annual number of births often will be heralded as a new baby boom—and, numerically, it is—but "fertility" as measured by the TFR may have remained absolutely constant.

TFRs vary from a current low of 1.3 in West Germany to a little over 8 in several countries, such as Kenya and the Yemen Arab Republic. For most developed states, a very recent TFR is usually available in country statistical yearbooks and vital statistics reports. Reporting of the TFR is often slower than the **crude birth rate (CBR)**, or births per 1,000 population, since it requires more detailed data to calculate. As a result, some developed countries may report a sharply declining CBR for a very recent year, suggesting that the TFR reported several years earlier may also have declined. An adjustment may be called for in such cases.

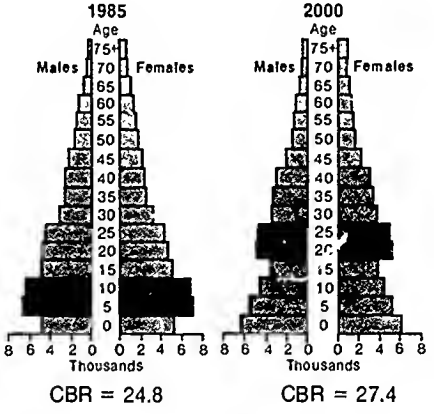
*An important distinction should be made at this point. The TFR is a *synthetic* measure. It sums up the fertility of all women at a given point in time, no individual woman is very likely to conform to the age-specific fertility rates of any specific year. It is the total number of children a woman would have if she had the same chance to give birth at ages 15-19 as all women of that age in a given year, the same chance at ages 25-29, and so on. If fertility is changing rapidly, the TFR can be a poor "predictor" of ultimate childbearing for any specific age cohort, such as women aged 15-19 in 1987. *Cohort* measures used in some projections trace the fertility of individual female age-cohorts.

For most developing countries, the task is much more complex or varied. An estimate of the TFR may possibly be available from the last census. Increasingly, more up-to-date estimates are becoming available from special demographic surveys. The World Fertility Survey (WFS) program, under the auspices of the International Statistical Institute with funding from the U.S. Agency for International Development which ended in the early 1980s, provides benchmark estimates of fertility for 41 developing nations, many for the first time. This important program has continued with the undertaking of the Contraceptive Prevalence Survey (CPS) and Demographic and Health Survey (DHS) programs, conducted by the Institute for Resource Development, Inc., a Westinghouse Electric Company. These surveys were taken as a joint venture with the statistical agencies of the various countries. In addition, some countries take independent surveys.

The value of these surveys is greatly enhanced when several are taken over a period of years and a time series can be evaluated—not that the results of even these specialized efforts can be taken at face value. The preliminary report on the 1981-1982 WFS of Nigeria listed a TFR of 5.7,[23] a fertility level which raised the eyebrows of most observers. The final report of the WFS gave a TFR of 6.3 children per woman, but then cautioned that result was subject to further study.[24] A 1982 survey in Ecuador reported a TFR of 4.4, based upon survey responses, but also labelled that result as "not realistic."[25] A recent analysis of survey data from Pakistan concludes that fertility declines estimated from the data did not occur at all—the TFR may have gone up—but result from the misreporting of children's ages.[26] Surveys taken over a span of years may show a rising birth rate, but this may be due to improved methods of interviewing as experience is gained in the special problems of conducting surveys in different cultures. Nonetheless, the continuing improvement in the confidence placed in estimates for many developing nations is

Box 2. Age Distribution and Population Change

The pyramids here demonstrate the effect of age distribution on population change. In 1985, this population has a noticeable "bulge" in the age groups 5-9 and 10-14, the result of a recent baby boom. In this population about half of all childbearing takes place in the 20s. When these groups reach the 20s, the number of births will rise disproportionately. In this example, the TFR is held constant at 3.1, as is mortality. In 1985, the crude birth rate is 24.8 per 1,000, but by 2000 has increased to 27.4, as a result of the larger childbearing population. The growth rate increased from 1.65 percent to 1.84.



CBR = 24.8 CBR = 27.4

largely a result of these surveys, the analysis they allow, and nearly universal censuses.

The selection of a level and pattern of fertility for the start of the projection will play a major role in shaping the future population picture and, therefore, must be approached with great care. The next task involves consideration of the rates at which a population loses members through death or emigration.

Selecting a Starting Mortality Level

Death, as Benjamin Franklin aptly observed, is certain for everyone in a population, as are taxes. Decreases in the death rate were the root cause of the post-World War II "population explosion," and future changes have significant potential, particularly when current life expectancy is low. Life expectancy at birth varies from 77 years in Japan to about 35 in Sierra Leone, a difference of over 100 percent. The lower life expectancies are associated with very high levels of infant mortality while today's high life expectancies contribute to the "aging" of a population.

Life expectancy is a product of *life tables*, one of demography's most powerful and useful tools. Life tables themselves are calculated directly from the *age-specific death rates* in a country. For example, 9 out of 1,000 males aged 55-59 die each year in Japan, while the figure in Mauritius is about 22 per 1,000.[27] These death rates are used to derive the life table rates of survival from age group to age group. Obviously, higher death rates at each age in Mauritius yield proportionately fewer Mauritians, compared to Japanese, at later dates. In short, the *survival* rates produced by the life table and used directly in the population projection process will be lower in Mauritius than in Japan. As a general rule, lower life expectancy results in lower survival rates at most or all ages.

Box 3. Surviving An Age Cohort

1985 Age Group 30-34		Life Table Survival Rate		1990 Ages 35-39
High life expectancy population:				
25,000	x	.98745	=	24,686
Low life expectancy population:				
25,000	x	.94222	=	23,556

The survival rates calculated in life tables and used here simply give the proportion of an age group which will survive five years until they form the age group five years older. Note that the number of survivors in the lower life expectancy country has 1,130 fewer survivors.

While, as might be expected, accurate life tables are available for most developed nations, reliable mortality estimates for developing countries are much more difficult to come by. Even among developed nations, since detailed data on age-specific mortality are more complex than other measures such as the crude death rate, countries are somewhat slower to report the needed data; it is also more likely that the years of reference will be further apart. Life expectancy data for 1985 may be on hand for the United States, but only for 1981 for Belgium.

Life tables of sufficient reliability are available for a growing number of developing nations, as evaluated by demographers on a case-by-case basis. More common is the use of *model life tables*, a consistently calculated set of life tables based upon the mortality experience of countries with sufficiently reliable data. Such tables offer a wide range of choices of mortality patterns which the user can attempt to match to whatever data are on hand. The most frequently used model life tables are those prepared by Ansley Coale and Paul Demeny, first in 1966 and recently extended in age coverage in 1983.[28] Another very useful collection is

published by the United Nations.[29]

Countries differ in their mortality patterns in a number of ways. Even with a similar overall level of life expectancy, one country may experience higher infant mortality or lower upper-age survival rates than another. To find the most appropriate model life tables, some indication, however crude, is needed for comparison with the life table values in the array of models provided. Methods of this type will produce reasonable results, though they are obviously dependent upon the degree of accuracy, or the inaccuracy, of the original data.

Having reached some conclusions on the population's death rates, one can turn to the only remaining possibility for change in a population, migration.

Choosing a Migration Pattern

Of the three components of change—fertility, mortality, and migration—the latter historically exerts the least impact on population growth or decline, at least at the national level. Many frequently cited projections assume that the effect of future migration will be nil, although there are some exceptions. Statistics from Norway, for example, report that net immigration was 3,761 in 1984, a significant amount in a country whose annual population growth is only about 11,492.[30]

Most countries of the world do not encourage immigration and are quite careful to control the amount permitted. Often, immigration may be viewed (cautiously) as a way to provide needed skilled workers until a native labor force can be trained, or to provide unskilled labor for jobs the resident population no longer wishes to do. Developed countries may at times be willing to accept immigrants from former colonies, but this attitude seems to be changing. In Africa, which historically experienced considerable free movement across borders, there is a growing unwillingness to tolerate and continue the practice. In some countries of Africa, such as the Côte d'Ivoire, a significant segment of the population consists of foreign-born workers. Nigeria ejected some 2 million aliens in 1983, perhaps half of whom were Ghanaian.

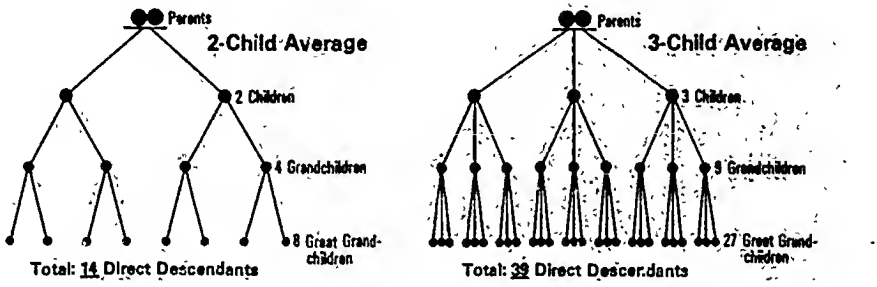
For a time, high immigration into the labor-short oil producing states of the Middle East were observed, often resulting in large proportions of immigrant labor. In Kuwait, three-fourths of the males over the age of 20 counted in the 1980 Census were non-Kuwaiti.[31] But, worldwide, the general trend has been towards limiting immigration. To be sure, some countries encourage *emigration* of workers since their remittance of wages back home are an important source of national income and foreign currency, but the pool of willing recipient countries appears to be decreasing.

Exceptions to this trend are the traditional receiver countries, such as the United States, Australia, and Canada; countries whose very growth and expansion owe much to immigrant populations, even in modern times. Not that these countries maintain unrestricted "open door" policies. Immigration laws are often drafted to select immigrants who will become contributors to the economy, although there are usually provisions for family reunification and refugees. Still, these countries are affected by immigration in important ways, and the effect of immigration is likely to be more significant in the future, as we shall see.

Where migration is significant, it is necessary to take the age and sex of the immigrants and emigrants into account as well as the number of migrants. It may be that a country receives immigrants in the younger working ages who subsequently return home at retirement or when they feel they have amassed sufficient funds. Estimates of emigration from the United States now used by the Census Bureau are higher than those used in the past.

Statistics, then, on immigrants and emigrants are available from quite a few countries and may be used when

Figure 3. Average Family Size Over Four Generations



deemed advisable. For most developing nations, few data are collected, although estimates could be derived if accurate data from two censuses and vital statistics were available, conditions rarely met.

Assuming that all of the basic data have been assembled and provide an accurate statistical picture of the population as of a given starting point, it is time to press on to an even more daunting task—predicting the future.

The Crystal Ball: Making the Assumptions

That last statement, of course, just slipped out. Projections, as we have said, are not predictions or forecasts, rather they are models of what will happen if this or that occurs. Some of the earlier Census Bureau projections for the U.S. did use the term "forecasts," but those projections spanned relatively short periods and the term was soon dropped.

The issue of forecasts versus projections has been the object of some debate. Philip Hauser has warned against the classification of projections as true forecasts:

> The social scientist as social scientist would be foolish to assume the burden of predicting the actual course of complex social events contingent upon conditions which he knows he cannot control either in a scientific nor in an administrative sense. To do so is to invite inevitable adverse reaction and loss of confidence.[32]

Hauser went on to say that the responsibility for predicting the future course of birth and death rates lies with the "social engineer," not the social scientist/demographer. But, as Donald Bogue pointed out, there is no group who can readily be identified as "social engineers."[33] Harold Dorn criticized the lack of statistical "backbone" on the part of those who issue projections, saying that, like it or not, projections will be both believed and used:

> It is no answer to the record to say,"The . . . estimates are not predictions. They are projections" . . . Predictions, estimates, projections, forecasts, the fine academic distinction among these terms is lost upon the user of demographic statistics. So long as numbers which purport to be possible future populations are published they will be regarded as forecasts or predictions.[34]

Demographers, then, will have to stand by their products in the long run no matter how many warning labels they may attach to their hesitant scenarios of the future. Demographers have done quite well in the technical aspects of projections, but they are far less adept when it comes to predicting "turnarounds" in important trends. Projections are essentially wholly dependent upon the underlying assumptions leading to their cre-

ation. That being said, on to a consideration of the assumptions themselves.

Fertility Assumptions. The demographer faced with the task of making an educated guess as to the future course of a country's birth rate must deal with three general cases, put in very broad terms. First, there are countries whose past fertility level has been high, at a level of 5-8 or more children per woman; second, there are those at "middle" levels, some 3-4 children; and, finally, those which have dropped to even lower levels, 2 children or less. While reviewing a country's fertility history, attention must be paid to its position vis-à-vis the **replacement fertility level.**

Replacement fertility is simply the level of childbearing at which individual couples "replace" themselves. This level is approximately* 2 children per woman in a population and we can simply refer to it as the "two-child family." When actual fertility remains constant at this level, a population will eventually cease growing and will remain stable in size, assuming no migration. Obviously, the countries in the first two cases cited in the paragraph above are "above replacement," and the third group is at or below replacement. These three varying situations present different problems when the task at hand is to project all countries for the purpose of deriving a world projection series.

If the populations below replacement are assumed to remain there, without in-migration, they will begin to decline at some point in the future and slowly disappear. Many countries find this unpalatable. If the countries above replacement are not assumed to decrease to the two-child family at some point, they will continue to grow, at varying but rather high rates—some in a situation that might be labelled "out of control."

Demographers would be the first to admit that they do not "know" what the childbearing behavior of couples will be 10, 20, 30, or 40 years hence. But an assumption about future fertility rates must be made or the projections cannot be run. We can visualize a computer screen testily asking for "Your Fertility Assumption?" Typically, the least controversial way out of the problem has been to assume that all countries will arrive at the replacement level at some future date and remain there permanently. This practice is equivalent to a rather wholesale application of **demographic transition** theory (see box). While there is little basis for such an assumption, there is perhaps less ground to assume that a country's fertility will eventually stabilize (if it does at all) at 3 or 1.5 children per woman either. Jean Bourgeois-Pichat has posed the philosophical question of whether fertility stems from the conscious childbearing decisions of couples or whether it might exhibit a wave-like pattern, rising and falling with an irresistible force of its own.[35]

The assumption of ultimate replacement is not entirely illogical. Classic demographic transition theory postulates that as countries industrialize and urbanize, their death rates will fall and then birth rates will also decline. This is precisely what happened in all currently developed countries and those developing nations with more advanced economies. Proponents of the demographic transition can justifiably claim that what is past is prologue. The theory does not support, nor indeed does it attempt to set, any particular "ultimate" fertility level. Even assuming that the demographic transition will occur elsewhere

*The actual level of replacement fertility will vary in a population depending on mortality. The figure of 2.1 children per woman is most often used, but this is only for a population with relatively high life expectancy at birth, 70 years or better. In Kenya, with life expectancy of about 56, replacement level today is about 2.25; in the U.S., it is about 2.06. Not all women survive to or through their childbearing years, so those who do need to compensate. Another reason for the 2.1 or so replacement level is the fact that there are about 105 males born for every 100 female babies and the replacement level is actually measured in terms of females.

Box 4. Demographic Transition

The theory of demographic transition offers a general model for the gradual evolution of a population's birth and death rates from the preindustrial to the modern pattern. A population goes through four stages:

Preindustrial stage. Birth rates are high and fertility uncontrolled, with the birth rate exceeding the death rate. Periodic famines, plagues, and wars cause brief periods of population loss. Examples are Sweden prior to 1825 and Mexico before 1920, as seen in Figure 4 on the following page.

Improvements in Mortality. With public health services and measures and more reliable food and water supplies, death rates fall and life expectancy is higher. If there is no accompanying decrease in the birth rate, the population growth rate rises.

Onset of Fertility Decline. At some point, usually as the country urbanizes and industrializes, the birth rate also decreases in response to desires to limit family size.

Modern stage. By this point, both the birth rate and death rate are quite low. Population size will remain stable if the TFR remains 2 children per woman, or increase slowly if it is a bit more than 2, but family size is small.

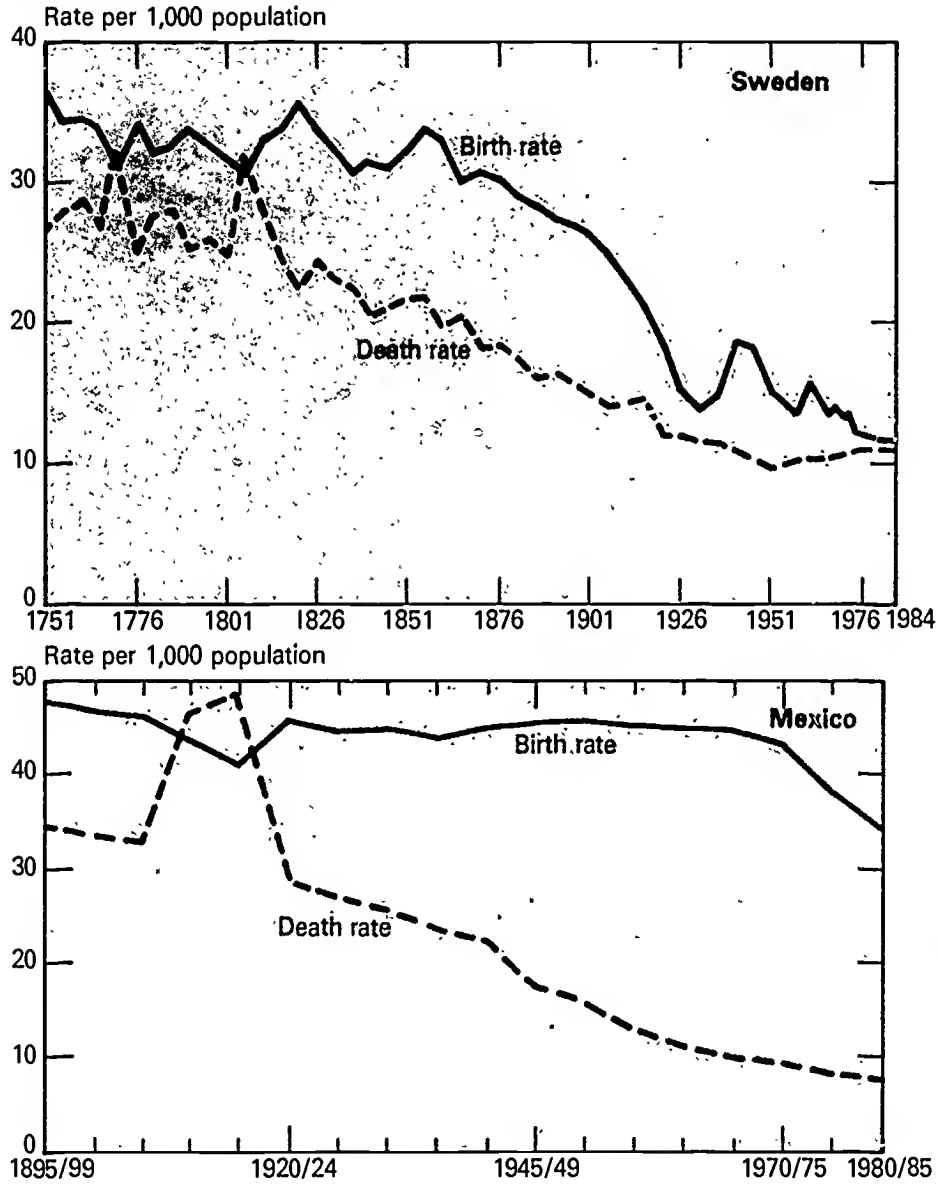
The transition has taken place in what are today's developed and fast-developing countries. It took about 150 years for Sweden's crude death rate to fall from 30 to 10 per thousand, but it took only some 40 years in Mexico. The more rapid decrease there is typical of developing countries which benefitted from the spread of modern medical and hygienic practices after World War II. But growth rates in developed countries never reached the levels of 3 percent or higher seen in developing countries today, as the process of transition was far more gradual.

and everywhere, the central question which must be addressed is the *timing* of the process. What might be seen as small differences in the pace of a country's movement towards replacement can make large differences in its ultimate population size. Will fertility in most developing countries drop precipitously as in China, at a slower, more hesitant pace as in Egypt, or not at all as thus far in North Yemen?

Selecting a pattern for future fertility in a country must take into consideration many relevant items: the government's policy on population growth, cultural attitudes towards family planning, the status of women, overall educational levels, the importance of agriculture in the economy, health conditions and services, among possible influences. Mathematical models for computers have been developed to assess the effect of numerous factors upon birth rates, and conclusions are drawn as to their relevance to the country in question.

Mortality Assumptions. While fertility exerts a major influence on a country's demographic future, mortality changes can also be quite significant. Declines in death rates, which were a major component of the rise in growth rates in developing states since World War II, continue in importance. A developing nation may experience a decrease in its fertility, but find the overall population growth rate remains the same, offset by a decrease in the death rate. In developed nations, a declining death rate will contribute to a larger proportion of the aged in the population. In countries where fertility is quite low and can be expected to remain so and where current life expectancy is high, virtually *all* change in natural increase or decrease will presumably come from improvements in mortality in the older age groups. In the developing countries, rapid postwar improvements in life expectancy are a root cause of the population "explosion" since they were often not accompanied by parallel fertility

Figure 4. Birth and Death Rates: Sweden, 1751-1984, and Mexico, 1895/99-1980/85



Sources. Sweden. Statistics Sweden, *1986 Statistical Yearbook* (Stockholm 1985), Mexico. 1895-1970. Francisco Alba-Hernandez, *The Population of Mexico* (Mexico. Center of Economic and Demographic Studies, El Colegio de Mexico, 1976), 1970-1985. United Nations Population Division, *Demographic Indicators by Countries as Assessed in 1984*, New York, December 1985, computer printout.

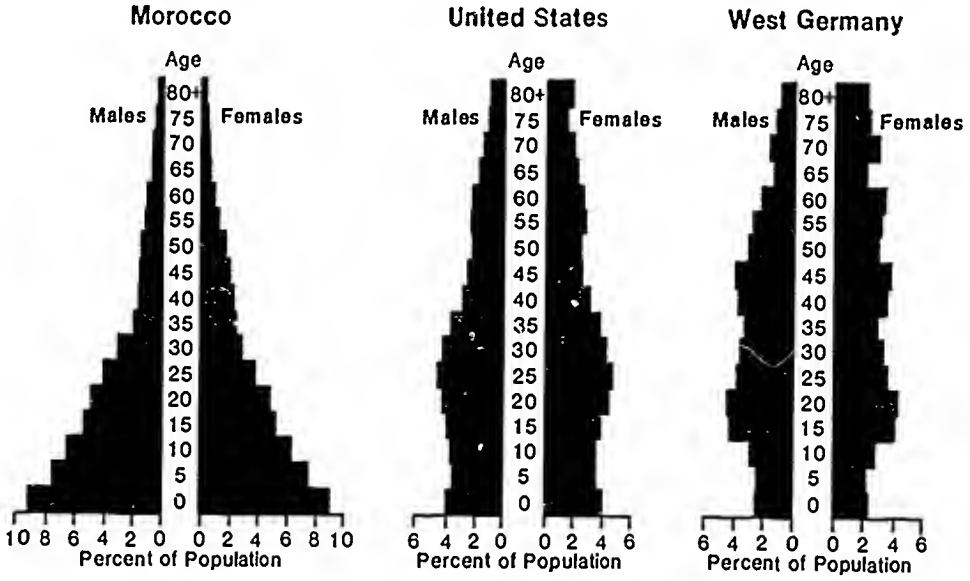
declines. In the industrialized countries, there has been some debate on just how high life expectancy can rise.[36] Many population projections have assumed maximum life expectancies of about 80 or 82 years at birth, a ceiling which is beginning to look much too low.

Life expectancy for females has already risen to 80 years in several countries such as Japan and the Netherlands and shows no sign of levelling off. This has important implications for governments and individuals alike. There were 32,000 centenarians in 1980 in the U.S.; they are projected to number (in a "medium" projection) 1.9 *million* by the year 2080.[37] And that "medium" projection assumes that life expectancy in the U.S. will peak at 81 years, although the Bureau does provide other ranges.

Increases in life expectancy at the older ages will result in ever-increasing proportions of elderly people, many of whom will require full-time care. There is already a new category of "old old" people, aged 85 and over. There has been much discussion over what to do in many industrialized countries with an expanding number of the aged making demands on pension, old-age, and health care systems at the very time that the relative number of younger workers to support those systems declines. In the United States, there is concern that there will be a "collapse" of the Social Security system. While that cataclysmic event is not likely in the coming decades,[38] there is already strain on the Medicare health system.

In the developing nations, life expectancies vary from an average regional low of about 51 years in Africa to 66 in Latin America. Infant mortality is often a major contributor to the overall death rate. In Bangladesh, infant deaths account for over one-third of all deaths; in the United States, that figure is approaching one percent. Part of the difference between

Figure 5. Three Patterns of Population Structure (1985)



the two countries, of course, results from the higher birth rate in Bangladesh, but the point to be made is that a rapid decrease in infant mortality in a developing nation will result in a significant rise in the overall rate of population growth, *ceteris paribus*. Kenya is an example of a country which has experienced a decline in mortality, but no associated decrease in fertility. The result has been a population growth rate of about 4 percent; if maintained, this rate would double Kenya's 22 million population in some 18 years. The combined effects of increasing life expectancy and high fertility can be seen in Kenya's age distribution: in 1983, there were 984,000 persons aged 30-34 in the country, but 3,900,000 children aged 0-4. This in a country which still has relatively high infant mortality and only moderately high life expectancy.

It is often overlooked that the rapid increase in population growth in the Third World was caused by sharp improvements in life expectancy after World War II, *not* by a rise in the birth rate. The impressive improvement in life expectancy is not solely a phenomenon of the developing states in modern times as the following quote illustrates:

> Abraham Lincoln's mother died when she was thirty-five and he was nine. Prior to her death she had three children. Abraham's brother died in infancy and his sister died in her early twenties. Abraham's first love, Anne Rutledge, died at age nineteen. Of the four sons born to Abraham and Mary Todd Lincoln, only one survived to maturity. Clearly, a life with so many bereavements was very different from most of our lives today.[39]

Indeed it was. Assumptions about mortality can be quite important, particularly when we consider that the mortality of the 19th century United States described above is experienced in many areas in developing countries today. As a general rule, the lower the life expectancy, the more uncertainty there will be concerning the future size of a population. This is especially true when present birth rates are also quite high (and this latter condition is nearly always the case). A country which sees a sharp decrease in its death rate from expanded public health services and improved sanitation, food, and water supplies, with no concomitant decrease in fertility is, simply put, in for a period of rapid population growth whose effects will be felt for decades to come. This rapid growth results from the large proportion of youth in high fertility populations, which in turn produces population momentum.

What of the assumptions? For developed countries, the issue is now and will be just how high life expectancy can climb. As heart disease declines as a prime cause of death, will cancer take its place?[40] Or will a previously unknown disease appear on the scene? Recently, Acquired Immune Deficiency Syndrome (AIDS) has made the latter question much less speculative, although most believe that its effect on overall life expectancy will be minimal. Oleh Wolowyna has made some preliminary projections for an African country and has determined that, even under drastic assumptions of infection, the impact on the rate of growth of a country would be limited.[41] While AIDS will have some impact affecting sexual behavior, it is doubtful that much of the current rhetoric on its demographic effect is justified.

But, in truth, we simply know very little about the future human life span. Perhaps we can all skip past the Biblical figure of "three score and ten," becoming new Methuselahs as science and technology overcome the aging process. It is likely, in any event, that more and more projections will be run with more liberal life expectancy assumptions. While it may seem difficult today to conceive of using an assumption of 100 years for life expectancy, such an "outlandish" procedure may not seem so strange in 2020 when centenarians are taken for granted.

For most developing nations, the problems posed by mortality assumptions are even greater. While the demographic transition model suggests that mortality will fall, normally before fertility, that is

Large families are the norm in many less developed countries. Inter-American Development Bank

largely based upon the experience of today's developed countries. Will the experience of France and the Netherlands apply to Nigeria and Bangladesh? These are the questions the would-be projector must face. If the assumption is that mortality will decline in a smooth, uninterrupted process, there will be large increases in population. Can Bangladesh support its projected 300 million people—a like number is projected for the entire United States—on territory the size of the U.S. state of Georgia alone?

There are countries with large populations in small areas. The Netherlands is one of the most densely populated countries on earth, with over 14 million people living in a land area about the size of Maryland (which has 4 million). West Germany's 60 million live in an area the size of Oregon (3 million). High density city-states such as Hong Kong or Singapore are often cited as evidence that population density and disaster do not necessarily go together. Again, we simply do not know.

The assumptions a projector wishes to make regarding future life expectancy for developing countries will benefit from an examination of the experience of other nations which have seen declines in death rates. Such declines have been due to such factors as the spread of public health, reliability of the food supply, the diversity of the economy, the distribution of income, and the ability of the political and social system to deal with rising populations, be they moderate or quite large.

In short, selecting an assumption for future mortality is no simpler than that for fertility. It should be emphasized, however—and emphasized over and over again—that few, if any, projections try to cope with the possibility of genuine social or economic disaster which could arise. Major famines, wars, or plagues are rarely considered in population projections primarily because one hesitates to predict the unpredictable. But the unpredictable has a rather persistent way of happening.

Assumptions on migration are somewhat less involved, or at least they are treated as such.

Migration Assumptions. As we have noted, a common assumption for future migration is that there will be no significant net flow of migration for most countries. This practice stems principally from

the joint reality that migration can be difficult to predict and that it is actually not a major component of change for many countries. It also results from a severe lack of data, particularly for developing nations.

In the developed nations, data are available for the small in-and-out-flows of migrants experienced by many countries and these could be incorporated in a projection if desired. The policies and laws of many developed countries are readily available and summarized in UN and other publications and form an excellent source for evaluation.[42] As we have noted, there seems to be a general trend of rising resistance against immigration. In the United Kingdom, work permits for foreign nationals are no longer automatically reapproved and that country has lately witnessed civil disorder due to ethnic and racial tensions stemming from its imperial past. West Germany has been somewhat chagrined to discover that many temporary *Gastarbeiters* admitted before the "oil shock" of 1973 to alleviate labor force shortages did not necessarily view themselves as "guest workers," but rather as permanent residents.

Even in Australia, Canada, and the United States, founded by immigrant settlers, immigration levels are controlled so that assumptions for the future have a relatively firm base. More serious difficulties arise when illegal immigration and refugee flows must be considered. It could be argued that America's national boundaries do not define a population, at least on a *de facto* basis. Cities such as Detroit, Michigan and El Paso, Texas are virtually international cities due to the patterns of daily commuting and traffic across the borders with Canada and Mexico.

For developing nations, some migration can be assumed when it is known that the country accepts or sends sufficient numbers of migrant workers to make it an important factor. These data may be inferred from census data on the foreign-born population in the receiving countries in many cases. Nonetheless, the flows are typically not large and are very difficult to predict. It may be that traditional receiving countries, such as the Gulf states, will send some foreign workers home when a sufficient native labor force is available, but that remains to be seen. Refugee flows, such as those from Ethiopia, from Cambodia, and from Afghanistan do create difficulties in projecting the populations of the sending and receiving countries, but it is difficult to predict the extent to which such moves are permanent. It is generally assumed that refugees will return home if and when peace is restored.

Immigration assumptions, then, are often quite conservative but may grow in importance in the future. In the developed countries, continued low fertility rates will result in immigration bearing an increased share, or even all growth, of population change as the number of births decreases relative to the number of deaths. Developing countries which have difficulty accommodating their population growth may seek to alleviate the situation by "exporting" workers, and it is also conceivable that occurrences of protracted food shortages may produce new groups of refugees as could new political upheavals, difficult to predict.

Having reviewed the process undertaken to set assumptions, we now need to ask just how reliable the resulting projections might be.

How Reliable Are Projections?

It depends. That is, to be sure, a rather terse way to answer the question.

Any answer to such a question could take two rather different approaches. Demography has developed accurate computational methods which give the results of changes in birth and death rates and in migration. But demography has proven less all-knowing when major shifts in those rates must be predicted.

There are a few basic rules of thumb which apply to all projections, albeit in a very general way:

1. The shorter the projection period, the more reliable the projection is likely to prove.

This self-evident principle simply means that a projection running from 1980 to 1990 is more likely to be closer to the eventual reality than a projection running to 2010.

2. The larger the geographic area being projected, the more reliable the projection is likely to be.

A projection for the continent of Africa is more likely to agree with the actual situation than one for Ghana alone. "Compensating errors" among the 53 countries of Africa may make the projected continental total population look quite satisfactory.

3. The lower the current birth rate and the higher the current life expectancy, the greater will be the reduction in the projection's likely margin of error.

This is based on the idea that a high-fertility, low-life expectancy country has the potential for a much larger degree of future change in its vital rates than does one with low fertility and high life expectancy.

The first "rule" is the least controversial, although a truly odd set of circumstances could result in a later date in a projection having greater accuracy than an earlier one.

The second "rule" is not subject to much disagreement, although it does bring up another interesting point. Much emphasis is given to the size of the "world" population both now and in the future. In the past year, a great deal of attention was focused upon the world population's passing the 5 billion mark. As to exactly when and where this occurred, one newspaper had "baby five billion" being born in Toledo, Ohio in July 1987, others claiming Yugoslavia, and other organizations saying it all happened in 1986.

But the more noteworthy numbers are those which track the population change at the more local level, particularly the country level. A projection of total "world population," after all, is merely the sum of all the somewhat-erroneous population estimates for the world's 200-plus countries. While a population projection for Africa of one billion for 2010 may prove quite "close," projections for individual countries may vary greatly from the "medium." And most problems must be dealt with at the national level. The projection for Gambia might prove too high, as matters evolve, but much too low for Rwanda, with serious implications for the latter. These errors may well cancel each other out so that the sum of projected population for Africa will appear quite accurate, but this continental total may mask a wide variety of errors at the country level.

Finally, the third "rule" simply reflects the expectation that countries with low fertility today, less than 2 or 3 children per woman, are less likely to show large future variations than countries with high birth rates. High fertility in Syria is expected to fall at some point, but few expect to see a country such as Sweden raise its fertility from 1.6 children to 3 or 4. At least, few *expect* that to happen. The same thinking applies to mortality rates: the question for developed nations centers upon just how high life expectancy can go, with the anticipation that it will continue to rise in small increments. Few expect major decreases in life expectancy. For countries with high death rates and life expectancies of 50 years or less, there is obviously a great deal of room for improvement. As these measures of fertility and mortality change in future, each following its own course, the eventual size of those populations will become more uncertain.

While there is much interest in the longer-range projections and the multiplying effect of "compound interest" makes for some fascinating speculation, the real value and greatest practical use of projections lies in the shorter term, say

Table 2. Illustrative Projections of Four Countries Under Varying Fertility Assumptions

(in thousands)

KENYA
(1985 TFR = 8.1)

If population achieved replacement-level fertility by:

	2000	2020	2040	2060	Constant Fertility
1985	20,600	20,600	20,600	20,600	20,600
2000	33,113	35,625	36,641	37,004	39,465
2025	48,915	61,083	79,308	86,121	131,143
2050	61,291	82,498	123,809	155,775	457,213
2075	64,368	91,911	155,428	212,809	1,606,683
2100	65,073	92,622	166,645	244,958	5,627,417

INDIA
(1985 TFR = 4.0)

If population achieved replacement-level fertility by:

	2000	2020	2040	2060	Constant Fertility
1985	758,926	758,926	758,926	758,926	758,926
2000	962,910	987,717	997,310	1,000,533	1,002,090
2025	1,225,139	1,323,968	1,441,119	1,482,570	1,684,524
2050	1,422,249	1,591,724	1,838,796	1,988,977	2,989,226
2075	1,479,805	1,697,543	2,066,202	2,323,548	5,376,599
2100	1,488,610	1,705,217	2,123,681	2,461,311	9,689,424

10 or 20 years. And this shorter span of time is precisely where they are more likely to be reliable.

Less Developed Countries

Since rules two and three above suggest that population projections for developing states will have a greater margin of error than projections for developed countries, we will treat those first.

No single issue is more important for the future population size of a high-fertility country than the timing of its approach to the replacement level. The potential for continued growth concomitant with high birth rates and a youthful age structure is astounding. One rarely looks at or hears of a projection which assumes that a particular developing nation will continue its high present birth rate, although that is the stated policy of some governments.

If we were to project the 1980 population of Mexico for 200 years, using these assumptions: a total fertility rate of 4.6 children per woman, life expectancy of about 63, and net emigration of 150,000 persons per year—the projection would result in a population of 6.8 *billion*. This, for a country with only a "medium" fertility level in 1980. Table 2 gives a similar illustration for Kenya. If one were to hold Kenya's fertility constant at about the current 8 children per woman and allow for gradual increases in life expectancy, Kenya's population would rise from about 20 million today to over 5 billion by 2100 and be doubling every 14 years. In 1981, the UN Population Division published the results of a similar illustrative exercise applied to total world population.[43] The UN stated that if fertility had remained at the 1975 level (it is only a little lower than that at

present, 3.6), world population would rise to 22 billion by 2050 and reach 150 billion by 2125—and be growing at a rapid rate. No wonder the population "explosion" attracted such attention in the 1960s!

It is further interesting to note that even if the above-noted UN "constant fertility" projection were reflected in subsequent events, it might not yet be noticed. The UN "medium" projection in the 1981 report, which assumed fertility decline to replacement in 2040 and an eventual stable population of 10.5 billion, put world population at 6.2 billion in 2000; but under the "constant fertility" assumption, world population would be only a little larger in 2000, 6.7 billion. In short, the truly enormous differences in such radically different projections do not appear in what people might perceive to be a "long" time, the quarter-century from 1975 to 2000. A like lesson might be drawn today, even as there are many reports of declining birth rates. The current world growth rate of 1.7 is only a little lower than the 1.9 of 1975, so the current downward trend must *continue* if very large growth of population is to be avoided.

These considerations apply, in the main, only to the developing nations which generally fall into three categories. There are those countries whose fertility has actually dropped to or below replacement level. These are few in number and are predominately small island nations or countries with relatively advanced economies, such as Barbados, Singapore, and South Korea. China, of course, is well known for its strong population program and remarkably sudden drop to near-replacement fertility in a basically rural country, although it appears that fertility began rising once again in 1986. There are those nations whose fertility has declined to medium levels, roughly 3 to 5 children per woman, including Indonesia, Thailand, Brazil, Mexico, and India. A major issue for some countries in this group is

CHILE
(1985 TFR = 2.6)

If population achieved replacement-level fertility by:

	2000	2020	2040	2060	Constant Fertility
1985	12,037	12,037	12,037	12,037	12,037
2000	14,756	14,850	14,934	14,957	15,054
2025	18,269	18,653	19,319	19,534	20,464
2050	19,613	20,271	21,608	22,370	25,515
2075	19,934	20,774	22,716	24,023	31,511
2100	20,022	20,861	23,018	24,736	38,705

WEST GERMANY
(1985 TFR = 1.3)

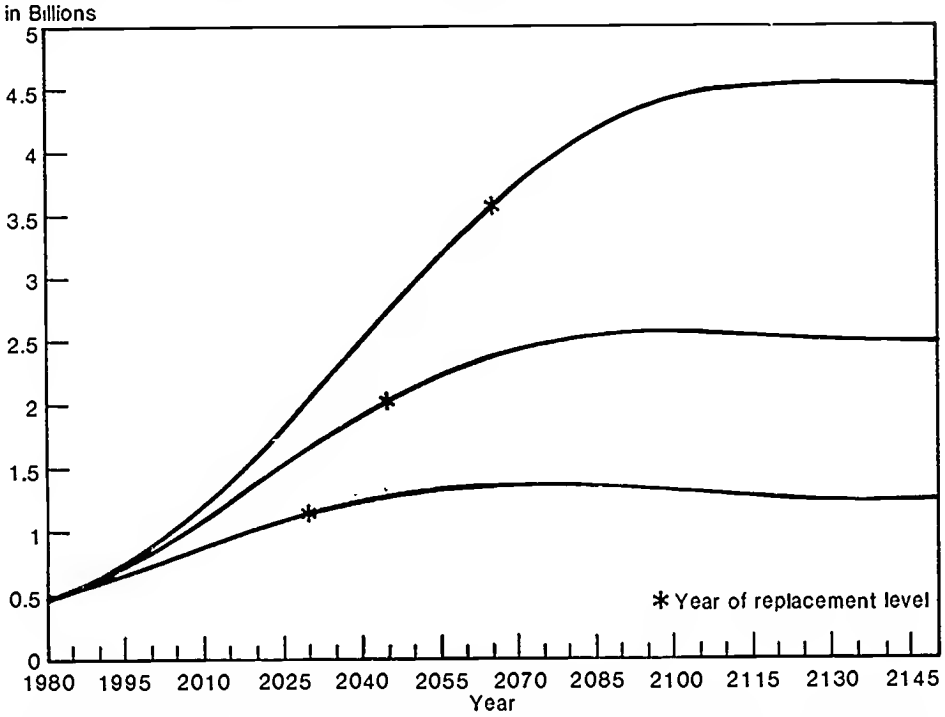
If population achieved replacement-level fertility by:

	2000	2020	2040	2060	Constant Fertility
1985	61,085	61,085	61,085	61,085	61,085
2000	60,505	59,243	59,243	59,041	58,612
2025	57,892	54,149	52,477	51,606	48,742
2050	54,346	47,980	44,294	41,681	34,389
2075	54,862	46,690	41,046	36,740	23,131
2100	55,750	47,387	40,840	35,340	15,451

Note: Projections assume gradually rising life expectancy in each case

Source: PRB projections utilizing basic data from the 1984 *Assessment* of the United Nations and the Council of Europe, "Recent Demographic Developments in the Member States of the Council of Europe, 1986

Figure 7. Population Momentum in Africa



When a country reaches replacement-level fertility, it might be expected that the population growth rate would immediately reach zero. However, if the decrease to replacement is comparatively rapid, the large proportion of younger persons in the population will cause growth to continue for some time. In the above UN projections for Africa, note that in all three variants the population continues to grow after replacement is reached

whether fertility decline will continue or has "stalled" at this middle level rather than proceeding to replacement. Egypt, Tunisia, and the Philippines are a few examples of the latter situation. Finally, there is the group with traditionally high fertility, 6 or more children per woman, with slight prospects of an immediate turndown. Nearly all the countries of Africa find themselves in these circumstances, as do Pakistan, Bangladesh, Iran, Syria, and others. Some of these countries have government policies to maintain the high birth rates.

The "constant fertility" projections cited above are clearly presented for illustration only. No serious observer expects a Mexico or Kenya with a population in the billions or a world of 150 billion with a still-climbing population. A more reasonable set of scenarios is provided by the well-known biennial *Assessment* of the UN Population Division. With the *Assessment* we can, for example, look at three possible population futures for Africa.

Today, Africa's fertility averages over 6 children per woman. In order to project the population, it is customary to make some assumptions on possible schedules of fertility decline to replacement level. The number of countries in Africa with policies to reduce the rate of population growth has very recently begun to

Table 3. Preferred Number of Children, European Countries

Country	Survey Year	Ideal Number of Children	Desired Number of Children	Total Fertility Rate/survey year
Austria*	1981/2	2.27	2.15	1.71
Belgium				
Flanders	1982/3	2.26	2.27	1.60
Wallonia	1980	2.31	2.26	1.69
Denmark	1983	2.2	—	1.39
France	1982	2.63	—	1.91
Ireland	1981	3.10	—	3.08
Italy	1984	2.22	—	1.53
Netherlands	1981	2.57	—	1.56
Norway	1982	2.51	—	1.49
Portugal*	1979/80	—	2.4	2.13
Switzerland	1982			1.55
Men		2.45	—	
Women		2.24	—	
United Kingdom	1981	2.41	—	1.81
West Germany	1981	2.38	—	1.44

*Women only

Source. Council of Europe, Exchange of Views on Opinions and Attitudes with Regard to Demographic Problems in the Member States of the Council of Europe. (Strasbourg: CDDE(86)2. 1986) Tables 1, 2, and 3

increase, but the continent is in the very early stages of that process. Kenya, which has had such a policy since 1967, also has the highest TFR, at 8 children per woman. Several North African countries had some early success in reducing their fertility, but the momentum seems to have run out of those programs. All in all, Africa's future population is a considerable question mark.

After evaluating the situation, the UN chose 2045 as the year in which Africa would reach replacement-level fertility. This results in a stationary population size of 2.6 billion for the continent by the latter part of the next century, up from 0.6 billion today. Of course, selecting that one year, 2045, and ultimately being proven correct would be a remarkable feat of prognostic marksmanship, so the UN issues other alternative scenarios as well. One, the "low" series assumes that replacement would come sooner, in 2030, while in the "high" series, it occurs later, in 2065. The projections thus contain a 35-year "window" of time during which it is likely that Africa will achieve the two-child family.

Given the genuine uncertainty over the future course of Africa's population, some would feel that even a 35-year span would represent a prescient prediction should it prove correct. But that 35-year difference produces a stationary population for Africa which numbers from 1.4 billion in the low series to 4.4 billion in the high. This *difference* of 3 billion people is equal to the total population of the *world* in 1960. Ranges for other regions are somewhat less when expressed as percentages, but are certainly impressive numerically. For Asia, the range varies from 4.3 to 6.2 billion (from 2.9 at present), and it goes from 0.9 to 1.9 billion for Latin America (from 0.4 today).

All of these projections, of course, assume that fertility will decline to the replacement level. Few ask *if*.

More Developed Countries

"Are We Having Enough Babies?" asked the cover of the June 22, 1987 issue of *U.S. News & World Report*. Their maga-

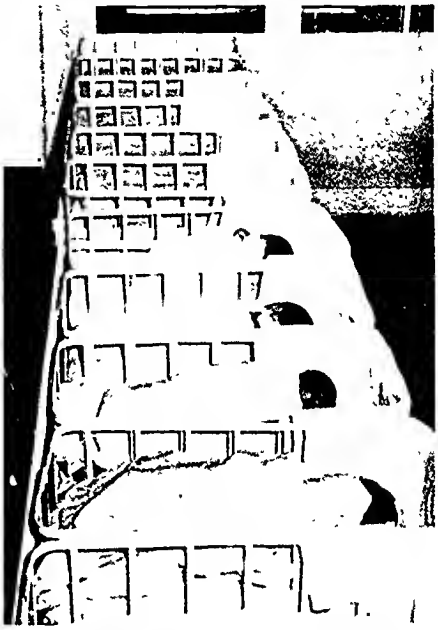
zine article points to a "new " feature on the population scene, the demography of low-fertility countries. Here, the demographer who has finished grappling with the problems inherent in projecting a decline to replacement in the developing countries, now faces the opposite situation. When will countries below replacement level once again rise to it? Or will they?

The issue is not a completely new one. Fertility was so low in many developed nations prior to World War II that fears of population decline were raised.[44] Fertility did not suddenly tumble in 1987, but had been quite low in industrialized countries since the early 1970s and even before then in some cases.

But this time around, there are new aspects of the issue. For one, birth rates are at historic lows and have remained low for quite some time. And, perhaps more significantly, the protracted "baby busts" have produced age structures which guarantee downward pressure upon the future number of births in many developed nations. Given the dual effects of age distribution and low fertility, the assumption one makes concerning the future reproductive behavior of couples in developed countries can have profound effects upon the population size of those countries.

West Germany receives much attention since it has the world's lowest fertility, 1.3 children per woman. Others with low fertility, 1.5 or less, are Denmark, Austria, Belgium, Luxembourg, the Netherlands, Switzerland, and Italy. The last country prompted the French journal *Population et Sociétés* to ask in April 1983,"Que se passe-t-il en Italie?" ("What's Happening in Italy?"). At somewhat higher TFR's of 1.6 to 1.9 are Finland, Norway, Sweden, the United Kingdom, France, East Germany, Hungary, Greece, Spain, Canada, the United States, New Zealand, Portugal, Iceland, Japan, Singapore, Hong Kong, Taiwan, and Cuba.

Even Eastern European countries whose governments encourage fertility



Harold M. Lambert

The future population.

have seen their rates drop more quickly in recent years; as a whole Eastern Europe stands at 2.1. Both Poland and Romania are at 2.3, Bulgaria is at 2.0, and Czechoslovakia is at 2.1.

The highest rates in Europe are found in Ireland, 2.5 and Albania, 3.3. The decline, then, is universal, crossing many cultural boundaries.

While a population size must decline if the fertility assumption used in the projections remains below replacement, the numerical error which results in different projections will be much less than would be expected in a developing nation. This is somewhat less true for the countries with the lowest fertility rates. If the lowest TFR, West Germany's, is held constant, the population will decrease from about 61 million today to about 50 million by 2020 and to about 15 million at the end of

the next century. The decline is much less dramatic in below-replacement countries with higher rates, such as the United States with a TFR of 1.8. By about 2035, annual births would begin to fall below deaths and would obviously result in a declining population. But that resultant "natural decrease" would be quite gradual in the U.S. and would likely be offset by continued immigration. At some point, perhaps when the population reaches the 300 million mark about 2080, immigration may no longer be sufficient and actual population decline would begin, although it, again, would be very gradual.

The concept of population decrease complicates the demographer's task. Does an assumption of protracted low fertility make sense? Is the current low birth rate in the developed states a temporary phenomenon? It could, perhaps, be viewed as a period of adjustment while society adapts to the changing roles of women. As better provision is made for child care and tax incentives reduce some of the financial consequences of having a desired second or third child, perhaps fertility will rise again. Leon Bouvier had speculated that the U.S. TFR of 1.8 children per woman in 1974 might simply be an aberration resulting from some delayed childbearing.[45] But, over a decade later, the TFR is still 1.8, suggesting that this figure is an indication of future U.S. family size. The childbearing decisions of couples, however, does not take place with the replacement level in mind. There is no innate urge in any population to seek the replacement level, as far as is known.

Some hint as to how to proceed on this issue can be gleaned from the assumptions countries themselves use when projecting their own populations. Many developed nations, including the United States, Canada, West Germany, and Denmark, now utilize an assumption of constant, below replacement-level fertility for the projection series they routinely publish. Others, such as the United Kingdom which assumes a return to replacement by 2008, do not.

Couples' fertility preferences in some developed nations have been surveyed. Preferences for 2 or more children are expressed, suggesting other factors are at work in below-replacement situations. It may be difficult, expensive, and cramped housing as in Japan or an expression of uncertainty about the future as reported in West Germany that keeps fertility low. These influencing factors can change but fertility rates may remain at the historically low levels they occupy at present.

No discussion of the reliability of projections would be complete without some review of past projections of the U.S. population and the well-known failure of demographers to have predicted the "baby boom."

In the late 1930s, Warren Thompson and Pascal Whelpton produced a series of projections against a background of the low birth rates and net emigration during the Depression years.[46] Their projections for 1980 ranged from a low of 134 million to a high of 158, the latter almost 70 million less than the eventual 1980 Census count, a huge "miss" for a 40-year period. To their credit, immigration was limited to 154,000 per year at the time and their high fertility assumption did allow for a TFR of 2.2, the rate of the early 1930s. In struggling with their assumptions, the authors commented:

> It seems far easier to judge what can be done in lowering death rates in the future than to judge what people may want to do regarding the size of their families.[47]

Truer words were never spoken, but things were to get worse before they got better. In 1947, Whelpton produced another series for the Census Bureau which predicted a peak population of 165 million in 1990 and a slow decline thereafter. The 1947 "forecasts" warned that the expected downturn in the postwar baby boom would require "heavy immigration" to offset the anticipated population decrease.[48] By the mid-1950s, the

apparent continuity of the baby boom caused Census Bureau projections to swing to the high side. These projections were to prove surprisingly accurate as the TFR rose to 3.6 by 1957. In 1953, the range of projections for 1975 went from 199 to 221 million[49] and the 1955 series gave a range of 207 to 228 million.[50] Since the 1975 population eventually proved to be 215 million, we can see that projections quickly gained in reliability, at least for the short-run period from the mid-1950s to the mid-1970s.

Major Sources of Projections

World Projections

The most often-cited world population projections are those of the UN Population Division. This series began in the 1950s with a group of regional reports giving population projections from 1950 to 1980.[51] The first was a projection for 1980 that appeared in the first issue, in 1951, of the UN's *Population Bulletin*. This early attempt predicted a world population in 1980 of 3.3 billion. While this projection fell far short—by over 1 billion—of the figure later estimated for that date, the number quickly rose in subsequent projections. By 1958, 4.2 billion was projected for 1980; today, a population estimate of 4.4 is used for that year. The lower figures used in the 1950s projections resulted partly from a lack of knowledge on the speed of mortality decline in developing nations and an underestimate of China's population.

In the 1950s, the UN found itself with a very large demand for population estimates and projections and very little data. This situation led to the evolution of a methodology not only for projections, but also for the development of current estimates, since so few developing nations had undertaken censuses. The data situation was so bad for Africa that no separate report was issued for that continent, while there were reports on the others. The dearth of both data and methods led the UN to develop a series of manuals describing techniques for estimating populations and their vital rates in the absence of reliable data. These manuals remain standard reference works for demographers to this day. In addition, the UN Statistical Office undertook the herculean task of systematically gathering demographic data from the world's countries and began to publish it in the annual *Demographic Yearbook*, starting with the 1948 edition, and the quarterly *Population and Vital Statistics Report*, from 1949.

Today the UN *Assessment* is published every two years and provides considerable detail on the population situation in the world's countries, including age-sex structure, fertility measures, annual births and deaths, infant mortality, and life expectancy for past and future dates. Three basic series are published covering the years 1950 to 2025—the "high," "medium," and "low" variants mentioned. The 1984 *Assessment* puts the world's TFR in 2025 at 2.7, 2.3, and 2.0 respectively and all countries are assumed to converge at replacement-level fertility. There have been reports of complaints from some developed countries with low fertility that an assumption of rising fertility to the replacement level is no longer appropriate. This may lead to changes in future issues of the projections.

The 1984 edition of the *Assessment* assumes that all countries will proceed along the demographic transition to roughly zero growth by ultimately maintaining the two-child family and that life expectancy will rise to a high of 75 for males and 82.5 years for females. Migration is considered negligible in most cases except for a few countries, such as the U.S.

The UN projections give the analyst or planner an invaluable tool with which to evaluate possible future demographic change, enhanced by the systematic manner in which they have been pre-

pared over the years. The conservative nature of the methodology provides the user with confidence that the projections are comparable from region to region and country to country. And the Population Division is careful to provide detailed descriptions of both the base data and the assumptions used. One may or may not agree with each specific assumption for every country, but the *Assessment* provides a consistent "yardstick' from which to begin an analysis.

Several issues must be kept in mind when using the comprehensive projection series, particularly at the country level. The length of time required for such a large task necessarily dictates that the estimates published were based upon data which may have been updated since the projections are actually received by the user. A population given for a country for 1985, or even 1980, may well be a projection based upon an even earlier census. When using the latest edition (the 1984 UN *Assessment*, for example) for a current year, such as 1988, these potential limitations should be kept in mind.

For example, looking at data for Iran, we note that a TFR of 5.2 is given for the period 1985-1990. While the actual situation in Iran is quite uncertain, given a lack of reported data and the war situation, most observers would believe that there has been little fertility decline in the country and that a more likely TFR is in the range of 6.5 - 7.0. Similarly, the TFR for China in the same period is listed as 2.1, but recently reported rates place that number at about 2.4 for 1986. This 1986 development would have been virtually impossible to anticipate when the *Assessment* was prepared. The various editions of the *Assessment*, then, are very valuable tools, but should be used in conjunction with more recent sources, when they exist.

The *Assessment* does not publish "long-range" projections on a regular basis nor does it venture country-level projections beyond 2025. The most recent long-range series was issued as a part of the 1980 *Assessment* and the results are shown in Table 4.

Table 4. Long-Range World Population Projections, United Nations and World Bank

(in millions)

	United Nations			World Bank
	High	Medium	Low	
1980	4,441	4,432	4,420	—
1985	4,866	4,826	4,779	4,840
1990	5,328	5,242	5,139	5,272
2000	6,337	6,119	5,837	6,176
2025	9,135	8,195	7,168	8,188
2050	11,629	9,513	7,687	9,523
2075	13,355	10,097	7,662	10,170
2100	14,199	10,185	7,524	10,414

Source 1980 *Assessment* of the United Nations Population Division and World Bank, *World Population Projections, 1987-88* (forthcoming).

The World Bank has prepared a well-known group of projections since 1978. These projections received much attention in the Bank's *World Development Report 1984*, whose theme was population and development. The Bank also projects the populations of individual countries on a long-range basis, to the "ultimate' stationary population in 2150. The results are not unlike those of the UN (see Table 4) but they do not duplicate the UN figures. The Bank also updates its series each year and publishes them biennially.[52] Only one series is produced, however, roughly equivalent to the UN's "medium" variation.

For its projections, the Bank assumes that all countries will reach the replacement level sometime between 2000-2050. The selection of a year is based on an equation which factors in female life expectancy, the country's TFR in 1985-1990 (taken from the UN *Assessment* or another source), birth rate changes in 1970-1980, and the status of family planning.

The Bank's single projection series concludes that world population will peak

Table 5. Population Projections of Major Regions of the World, 1985-2025

(in millions)

	United Nations "medium"			World Bank			U.S Census Bureau		
	1985	2000	2025	1985	2000	2025	1985	2000	2025
World	4,837	6,122	8,206	4,840	6,176	8,188	4,882	6,241	8,675
Less developed	3,663	4,845	6,809	3,663	4,913	6,850	3,706	4,971	7,324
Africa	555	872	1,617	560	871	1,495	569	886	1,686
Latin America	405	546	779	398	529	715	409	551	789
Asia & Oceania	2,703	3,427	4,414	2,704	3,513	4,639	2,728	3,534	4,837
More developed	1,174	1,277	1,396	1,177	1,263	1,338	1,176	1,269	1,351
USSR and E Europe	391	435	499	389	426	469	391	428	484
Other developed	783	842	897	788	837	869	785	841	867

Note More developed countries comprise all of Europe and North America the USSR, Japan in Asia, and Australia and New Zealand in Oceania Yugoslavia is included in other more developed countries

Sources UN Population Division 1984 *Assessment* World Bank *World Population Projections, 1987-88* (forthcoming), U S Bureau of Census, *World Population, 1987*, (forthcoming)

before reaching 11 billion in the latter part of the next century. This is quite similar to the UN's thinking and, for most countries, the results are quite close, at least in the short run. Differences that do exist are attributable to the selection of a somewhat different base population, possibly as a result of varying undercount adjustments and some the use of different future paths of fertility and mortality [53] While the Bank's projections do not as yet include historical estimates back to 1950 which the UN includes, they do contain more detail on smaller countries such as Tonga and some countries the UN cannot treat separately such as Taiwan The Bank also publishes its results more quickly. All in all, both sets of projections enhance the analysis of future possible populations and provide valuable insights when used side-by-side.

The U.S. Bureau of the Census' International Demographic Data Center (IDDC) also conducts detailed evaluation of country populations, the results of which are published in its *World Population* series Some results are shown in Table 5 The most recently published version, *World Population, 1985*, gives country populations from 1980 to 2000. The last detailed set was published in 1979 in support of the President s *Global 2000* study.[54] Details on a specific country can be obtained by contacting the Bureau directly.

Other series of projections have been run and made public by demographers. One such series was prepared in 1978 by Donald Bogue and Amy Ong Tsui at the University of Chicago, and the results used in a publication of the Population Reference Bureau. They assumed that family planning would be more effective than other projections normally do, resulting in future world totals much lower than those of other series.[55] The projections produced quite a controversy at the time, with numerous headlines on the "end of the population explosion" and questions from other demographers.

National Projections

Projections are prepared by national statistical agencies and are routinely published in statistical bulletins and year-

books The U.S. Bureau of the Census, for instance, has been publishing projections for America since the 1940s. The most recent series, issued in 1984, gives projections to the year 2080 and made a bit of history as the first set to incorporate an assumption of continued below-replacement fertility as the "middle" series.[56] The middle series, the most often-cited, assumes that immigration to the U.S. will continue at a *net* of 450,000 and that life expectancy at birth will rise to an average of 81 years. The TFR is assumed to settle on a value of 1.9 after rising briefly to 1.96 from today's 1.8.

How reliable are these projections? Why should they be given credence when we are aware of the baby boom debacle and other errors of the past? To begin with, U.S. fertility has been quite stable for over a decade at about 1.8 children per woman. Legal immigration can be problematic, as Congress may legislate new immigration laws. Emigration and illegal immigration are still in question, but the Census Bureau has been grappling with this problem and refining estimates. Life expectancy is high and, while future changes are expected to be gradual, this trend bears watching. An insight into future fertility may be the factor with the greatest variability, but we are at least fortunate to have evidence from the Census Bureau's Current Population Survey's questions on birth expectations asked every June. In the 1985 survey, women aged from 18 to 34 reported that they "expected" to have about 2.06 children each. This value has ranged from 2.0 to 2.1 since 1979 and was 2.2 in 1976. But, during that time, the period total fertility rate has been somewhat lower, 1.8. This may be partially explained by the Census Bureau's report noting that 40 percent of the women surveyed said that they were either uncertain about their expected number of births or did not respond, and such women have been shown to eventually exhibit lower birth expectations when they do respond.[57]

Since the 1984 projections were released, a few changes have been made in the assumption of immigration used in the monthly U.S. population estimate. Responding to criticism that the net immigration assumption of 450,000 was "too low" in view of an unknown amount of illegal immigration, the Bureau increased immigration by 200,000, based upon its estimate of undocumented immigrants who arrive in the U.S. to take up residence. At the same time, the Bureau also changed its estimate of emigration from 36,000 to 160,000. This had the net effect of adding about 76,000 more persons to the population per year, a negligible amount.[58]

The Bureau actually issues 30 series of projections so that users can select the series each finds most acceptable. While Series 14, the middle series shown in the greatest detail, is used most often, there are users who prefer series 17, which differs from 14 only in its higher immigration assumption (a net of 750,000 per year), because they feel that the middle series assumption is too conservative. In fact, the projections for the 2080 population range from 191 to 531 million!

Many countries publish projections, some routinely, some in connection with national economic plans, or to support the implementation of population policies.

Subnational and Local Area Projections

Interest in projections extends far beyond data at the national level. Projections of the populations of states, provinces, counties, and cities are frequently produced to assist planners and businesses in many ways. A company might be interested in a city's projected labor force for the possible location of a new plant. A Board of Education will need to consider the projected number of school-age children with an eye to increasing or decreasing the future number of teachers and classrooms. Highway planners re-

quire the sufficient advance warning that projections can provide to design their capital projects to meet the needs of changing population distribution.

Demographic projections are often a vital part of the planning process but must also be considered along with other factors. The business firm contemplating a plant location may note a labor force that is projected to be potentially inadequate for their needs, but an attractive tax rate and climate along with convenient rail transportation may prove to be more important. The company will have to implement measures to attract enough workers—but at least it will know that in advance. The school board may discover that, while its school-age cohorts are growing only slowly, the younger families are settling in more distant suburbs. This may warrant the construction of expensive new schools, while the projections may suggest that it would be appropriate to convert existing school facilities into centers for the use of the growing number of people over 60. Projections may even be used as a basis for the type of population policy in which a local government restricts the number of new housing permits issued to control growth until needed facilities and services can be planned and constructed. It may even be that projections have a self-fulfilling aspect. If an area is "forecast" to grow, roads and shopping centers may be built in anticipation of future needs, raising the area's attractiveness so that it does grow.

Subnational Area Projections

Subnational projections are often more difficult to produce and exemplify the principle of "the smaller the geographic area, the more error one may expect." The single largest contributor to this increased margin of error is migration. The more slowly fertility and mortality can be expected to change, the greater the variation that will be introduced by migration.

In the U.S., the Census Bureau produces projections of the 50 states and the District of Columbia by age and sex to the year 2000. This is a complex process which must take into account different state fertility levels, from a 1980-1985 Massachusetts TFR of 1.5 children per woman to Utah's state TFR of 3.3. Projected rates are consistent with those used in the Census Bureau's national-level middle series—again, note the use of the middle series. State life expectancies, which vary from 80 in Hawaii to 68 in the District of Columbia, are also taken into account.[59] For migration, the 1980 Census question on one's residence five years previously provides a detailed source of interstate migration paterns. One can, for example, learn that 921 persons who lived in Michigan in 1975 lived in Vermont in 1980, while 464 migrated in the opposite direction.[60] These data were not, in fact, available when the Bureau issued its state projections in 1983,[61] but will be included in a revised series due shortly. The individual state projections are then adjusted to the independently-projected national totals.

Migration is the most troublesome issue. A consistent set of migration assumptions is needed for state projections. It would be illogical to base the assumptions on an individual assessment of each state with no attention paid to the overall interstate pattern. In short, a state's migration must be based upon an appropriate share of all projected migration. The Bureau, in 1983, used estimates of net migration patterns for the 1970-1980 decade derived from the censuses of 1970 and 1980.

The often capricious nature of migration can upset the results of local projections in short order. Many areas of West Virginia are dependent upon the coal industry. The movement of workers from the northern "Rustbelt" to the rapidly growing southern "Sunbelt" states will likely only last as long as there are jobs at the other end. With the current "oil bust," this attraction has diminished. It also now appears that Ohio will not lose population

as rapidly as expected nor will Oregon's grow. Again, this is all speculative. Perhaps one migration "stream" which is likely to continue is that for retirement. If so, projections for Florida may prove rather accurate. The Bureau's projections, which are published by age and sex, provided other insights. In studying them, we can see that nearly all growth in the U.S. population over the age of 65 is projected to be in the states of the South and West, hence the recent coinage referring to the "graying of the Sunbelt."

The Census Bureau state projections illustrate the hard choices that must often be made. Since migration is so difficult to predict, the Bureau assumed in its 1983 series that the migration pattern of 1970-1980 would remain constant. This procedure generally gave reasonable results, although the high out-migration from the District of Columbia in the 1970s caused the District's projected population to drop from 638 million in 1980 to 377 million in 2000. In this one instance, the assumption did not work as well and the population of the District actually levelled off after 1980. The District is, however, a particular case in that it is a city and not a state, although it must be treated as a "state equivalent."

The Bureau does not project populations below the state level, although research has been conducted into the possibility of county projections. As the geography of projections becomes smaller, the effectiveness of the cohort-component method begins to break down. This is due both to a decreasing likelihood of data availability and possibly to a less coherent basis for assumptions. Several commercial firms such as Donnelley Marketing Information Systems, the National Planning Data Corp., and CACI, Inc. do produce projections of smaller areas, primarily to help target audiences and markets.

Other methods have been used which seek to tie population growth to projected employment. The Bureau of Economic Analysis of the U.S. Department of Commerce uses economic outlooks to project employment for states and metropolitan areas.[62] The Bureau of Labor Statistics in the Department of Labor uses econometric modeling to project the labor force. State demographers often base projections on land use and housing.

An excellent summary of local area projection methods can be found in the Census Bureau technical paper written by Richard Irwin.[63]

Subgroup Projections

Another type of "subnational" projection pertains to specific groups in the population. This might be an ethnic group such as Hispanics in the United States or persons of foreign stock in West Germany. Or specific attention may be focused on the coming labor force or the numbers of elderly. Projections of households and families may be run or a more specialized series on the voting-age population may be deemed useful.

In the U.S., the Census Bureau has routinely projected the populations of whites, blacks, and "other races." More recently, the Bureau has responded to public interest in issuing its first set of projections for the Hispanic population in the U.S.[64] This particular population presents additional difficulties for a projection since its definition is less clear-cut than that of racial groups such as blacks or Asians. And, until recently, there has been a lack of fertility data specifically on Hispanics. That situation has been alleviated to a large degree by the National Center for Health Statistics program to include Spanish origin on birth certificates.[65] Given the uncertainty over many parameters of the Hispanic population, particularly immigration, it is not surprising that the projected population in 2080 ranges from 35 million in the lowest series to 141 million in the highest. Users would, perhaps, be wiser to use such projections for a shorter range—and to read the Bureau's detailed description of its methodology and assumptions.

Thus projections can take many forms below the national level in response to the wide variety of the needs of users. Many such series are tied to national-level "control totals" to keep things from getting out of hand. If they are not, the user would do well to find out the reason.

What of the Future?

Today is an exciting time for those who make or use population projections. Exciting, since these decades are seeing the most rapid and diverse population growth in human history. The next few billion people are projected to be added at a rate of 11 or 12 years each—and only if the world birth rate continues to come down. Countries with but 15 or 20 million population a scant few decades ago, now project populaces in the hundreds of millions. More and more uses are found for projections at all geographic levels as users in business and planners increase their understanding of the process and appreciate their irreplaceable nature. In some ways past projections have proven relatively accurate because birth and death rates were changing more slowly, particularly in developing countries. But no longer. As more and more countries undergo fundamental change in their family size and life span, projections will become more outdated more quickly.

A world of 7 billion or 14? Or more? We simply do not know. Will a new regime reverse China's one-child population policy, labelling the present one "revisionist"? Can India's 800 million, currently hailed as "self-sufficient" in food, absorb the additional 800 million projected for it? When we routinely insert fertility assumptions into the population projection of a country, should we not consider the many other issues we are implying? A two-child family Africa? What does that say about the enormous social and economic changes in that region? Population projections implicitly make sweeping assumptions about a complex fabric of human values, cultures, social mores, religious beliefs, and family structures. Users of projections are wise to keep this in mind at all times.

President Lincoln, of course, could not have known of the changes to come in the world when he made his speculation, nor can we today. We could, for example, imagine the conversations prognosticators of 1888 might have had about the world of today. It would have made entertaining listening, as would our descendants' eavesdropping on our comments today. □

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Microcomputer Programs for Population Projections

The availability of the following programs may vary as do prices, although any charges are typically minimal. Contact the sources directly for details. All are for IBM PC and compatibles.

PROJ5 An adaptation of the U.S. Census Bureau program for micros. Projects for a 50 year period at a time. 192K RAM required. No interactive data entry. Spanish and French versions also available.

IRD at Westinghouse
P.O. Box 866
Columbia, MD 21044
Tel: (301) 992-0066

FIVFIV Projects for a 35-year period and very detailed results. Includes UN life tables as well as Coale-Demeny. 256K RAM required. Interactive data entry available. Contains option to produce single year data by age in SINSIN module. Optional math coprocessor.

The Population Council
1 Dag Hammarskjold Plaza
New York, NY 10017
(212) 644-1300

CELADE No time limit on projection period. Very complete output with somewhat difficult data entry. 384K RAM required, also includes UN life tables. Optional math coprocessor.

CELADE
Population Documentation and Data Processing Division
Avenida Dag Hammarskjold
Casilla 91
Santiago, CHILE

DEMPROJ A package designed for simple data entry for projection of 5- to 50-year period. Output has little detail 256K RAM required Includes graphs and pyramids which require graphics card.

The Futures Group (203) 633-3501
76 Eastern Boulevard
Glastonbury, CT 06033

ESCAP/POP Projects for unlimited time period Produces graphs which require graphics card. RAM requirement unknown.

ESCAP/Population Division
United Nations Building
Rajdamnern Nok Avenue
Bangkok 10200, THAILAND

ILO Projections for population and labor force with nice graphics and pyramids.

Employment Planning and Population Branch
International Labor Organization
4, route de Morillons
Geneva 22, Switzerland

FUTPOP Quite complete program with provision for single-year results.

Department of Sociology (716) 275-3163
University of Rochester/River Campus
Rochester, NY 14627

IMPP—An Integrated Multiregional Population Projection Model
Complex projection package for multiregional projections. Complete with interactive screen editor. Comprehensive series and modules for estimating parameters. 256K RAM requirement.

Center for Development Policy (919) 541-7218
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

NOTE: This listing draws upon information contained in McGirr, Nancy J. and Shea O. Rutstein, *Comparison of Microcomputer Population Projection Programs*, paper presented at the annual meeting of the Population Association of America, Chicago Il, April 29-May 2, 1987.

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